Industrial QUALITY CONTROL

Vol. XII, No. 5
NOVEMBER, 1955

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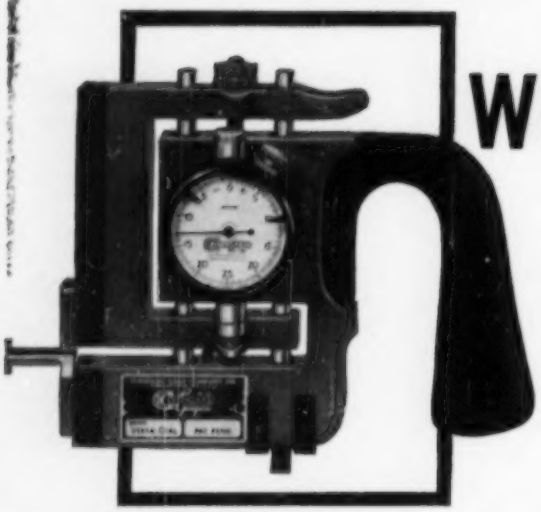

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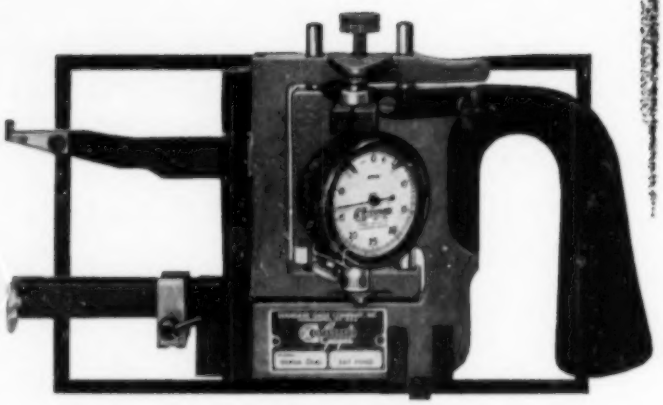

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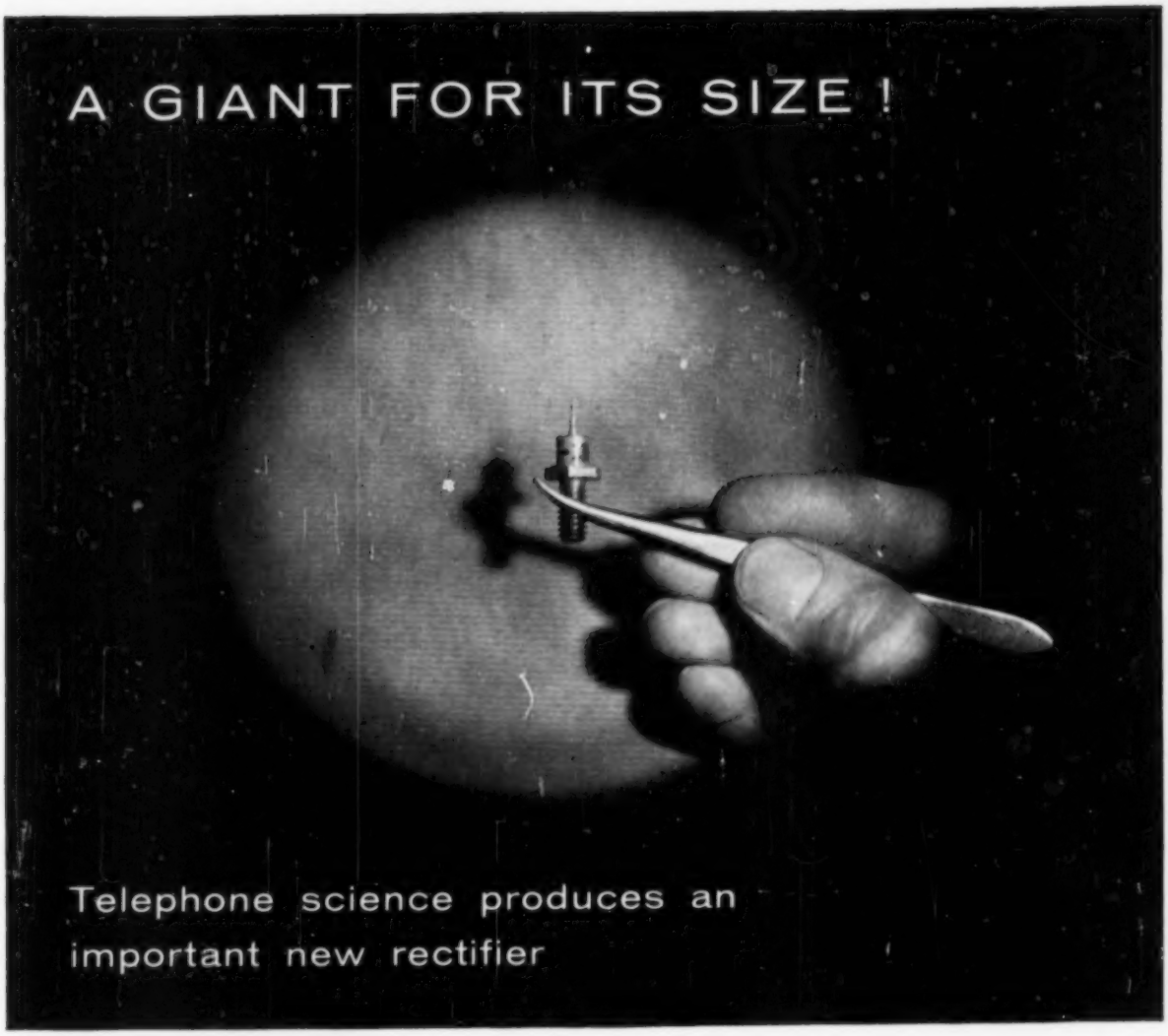

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From the Scrap Box

Support Your QC Source Inspector

THOMAS J. BYRON
USAF QCR, Hughes Aircraft Co.

This article is written in defense of a quality control source inspector whose job it is to visit sub-contractors plants and accept or reject material for the prime contractor. Prime contractors have a tendency to take too many things for granted, and quality control source inspection is one of them.

Each QC source inspector should carry a full security clearance up to and including secret, as he will visit plants of sub-contractors many of whom will be working on orders from prime contractors whose contracts are secret. This places the sub-contractor in an embarrassing position. He does not want to lose the business of the prime contractor the QC source inspector represents by refusing him permission to enter the plant and inspect the material, yet he is bound by security rules which force him to do so. Time is lost while corrective action is in process of completion.

While in the field the QC source inspector encounters many problems, some of which could have been eliminated if the prime contractor exercised a tighter control in screening purchase orders. Enumerating a few:

1. Dimensions omitted from the drawing by the engineer
2. Improper or defective molds furnished to the sub-contractor by the prime contractor
3. First article inspection not called out on the purchase order
4. Improper packing and packaging call out on the purchase order, causing "busts" in shipment
5. Insufficient information furnished to the purchasing agent placing the order
6. Failure of the prime contractor to furnish his source inspector with an up to date qualified products list
7. Verbal dimensional changes given over the telephone without written follow-up confirmation, causing errors and arguments
8. Failure to immediately notify the inspector and the vendor when discrepancies are noted at the prime contractor's receiving department
9. Too much time consumed at the prime plant on the paper work preparatory to processing a change order—the purchasing agent gets it three days late and the vendor has run another hundred parts that will obviously be obsolete and scrapped.

(Continued on page 21)

Industrial Quality Control

Vol. XII **NOVEMBER, 1955** **No. 5**

Table of Contents

ARTICLES

Statistical Technique for Forecasting Sales
Guy C. Parkin 5
Quality Control in Paper Finishing
Edward R. Hoffman 7
Statistical Design in Electronics Production-Line Experimentation
Frank Caplan, Jr. 12
Statistical Design of Experiments in Metallurgical Research
Saul Gilbert 13
Statistical Principles of Testing
John Mandel 18

DEPARTMENTS

From the Scrap Box 3
Local Sections News 22
Bibliography
Joseph Movshin, Editor 32
What's New?
Roy Wylie, Editor 34
Positions Wanted 39
Positions Available 40
Consulting Ads 40

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GEORGE R. FOSTER,
Managing Editor.

Sworn to and subscribed before me this 28th day of September, 1955.

LILA H. MEANY,
Notary Public.

(SEAL)
(My commission expires September 14, 1958.)

OUR COVER

This month's cover picture, shows employees of the Hammermill Paper Co. in a dual operation; manually sorting for defects and counting sheets of paper. Edward R. Hoffman's article, "Quality Control in Paper Finishing," begins on page 7.

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Statistical Technique For Forecasting Sales

GUY G. PARKIN

Minnesota Mining & Manufacturing Co., St. Paul, Minn.

This article is intended to be an exposition of a concept concerning a mathematical approach of applying scientific principles to sales forecasting and allied factors. Sales forecasting is a fascinating subject. This is illustrated by the following remark overheard at one of the quality control conferences: "You know, these SQC engineers sure go all the way. They have been and are predicting the quality capabilities of our industrial repetitive processes, and now, according to this sales forecasting article, they are going to tell us how much we are going to sell. This I have to hear."

The source of interest of the Minnesota Mining and Manufacturing Co. in sales forecasting originated in the sales inventory department. Prior to the use of statistical quality control procedures our estimates of sales were unduly influenced by opinions as to competition, obsolescence, advertising and national emergencies. The amount of variation of the estimates from the actual sales was unknown. The primary problem of the quality control engineer was to improve the estimate and to indicate something of the variation which might be expected between the estimates and the actuality.

It was recognized that the following benefits would accrue if a valid forecast of sales could be made:

1. A contribution to the control of raw material purchasing which would cover optimum investment, warehousing, and service to the production department
2. A contribution to better vendor relationship, particularly with reference to quality
3. A contribution to economics in scheduling production by the reduction of variation in the raw materials
4. A reduction of the space used in the warehouse
5. A reduction in unwarranted expense in correspondence, telephone calls, telegrams, invoice writing, clerical work, and administration
6. A contribution to more economical transportation of the finished product from factory to sales distribution branches.

Basic Concepts of Sales Forecasting

Sales forecasting of a product which has been supplying a diversified market over a relatively long period of time is necessarily based on sales history. Although the arithmetic average of past sales may be tempered with management's systematic plans, intuition, and judgment, there is a real need for a tool indicating the occurrence of significant departures from the expected. The further in advance of actual production this tool can perform its function, the more valuable it becomes relative to economical purchasing of raw materials, scheduling, production, inventory, and transportation.

We have attempted to evaluate unsubstantiated fluctuations with a control technique designed to indicate automatically invalid behavior relative to history. We take action whenever two successive values on the same side of the mean fall outside of the control limits set two standard deviations from the mean. Assuming the factors involved are of a random nature, we can calculate the probable variation for individual months, using statistical concepts. The mechanics of the technique are not difficult and can be operated by average clerical personnel.

Technique

The "Work" Form is indicated in Table I:

Cols. 1 and 2. The history sales data for the previous year from which we will forecast behavior for the current year

Col. 3. Cumulative monthly sales (observed)

Col. 4. Average cumulative monthly sales (expected, if we had no variability)

Col. 5. Difference between expected and observed (monthly cumulative sales error)

Col. 6. The plus and minus errors are respectively squared, then added, divided by frequencies, and a square root taken. This value is the standard error of estimate, which is the root mean square deviation of the actual cumulative monthly values from the average cumulative monthly values and can be used to estimate the percent of deviations that should fall within specific limits. One standard error should include approximately 68 percent of all random deviations, two standard errors should include approximately 95 percent and three standard errors should include over 99 percent of all random deviations.

The hypothetical values used in Table I reveal a mean, $\bar{X}$, equal to

TABLE I

TYPE 560	ACTUAL SALES	X CUMULATIVE Actual	X' CUMULATIVE Average	X − X'	(X − X')²		
JAN. — 1951	17.3	17.3	9.34	+7.96	63.36		
FEB. — 1951	3.4	20.7	18.68	+2.02	4.08		
MAR. — 1951	6.4	27.1	28.02	−0.92	0.85		
APR. — 1951	7.9	35.0	37.36	−2.36	5.57		
MAY — 1951	10.4	45.4	46.70	−1.30	1.69		
JUN. — 1951	10.0	55.4	56.04	−0.64	0.41		
JUL. — 1951	7.8	63.2	65.38	−2.18	4.75		
AUG. — 1951	12.4	75.6	74.72	+0.88	0.77		
SEPT. — 1951	10.9	86.5	84.06	+2.44	5.95		
OCT. — 1951	9.2	95.7	93.40	+2.30	5.79		
NOV. — 1951	9.6	105.3	102.74	+2.56	6.55		
DEC. — 1951	6.8	12)112.1	112.08		11)99.27		
		9.34			9.024		
		$\bar{X} = 9.34$			$\sqrt{9.024} = 3.0$	$\sigma_4 = 3.0$	

TABLE II

TYPE 560 IDENTITY		NET INV.	SHIPPED	GROSS INV.	ACTUAL SALES	CUMULATIVE SALES	$\bar{X} \pm 2\sigma_d$ CAPABILITY LIMITS		DATE	$\bar{X}$	σ_d	$2\sigma_d$	$3\sigma_d$	Coef. of Var.
									1/52	9.4	3.0	6.0	9.0	31.9%
									5/52	11.5	3.7	7.4	11.1	11.5 × 0.319 = 3.7
JAN.	1952	...	...	*18.4	11.4	11.4	3.4	15.4	*9.4 + (3x3.0) = 18.4					
FEB.	1952	7.0	9.4	16.4	10.6	22.0	12.8	24.8						
MAR.	1952	5.8	9.4	15.2	11.1	33.1	22.2	34.2						
APR.	1952	4.1	9.4	13.5	12.2	(45.3)△	31.6	43.6	Out Control					
MAY	1952	1.3	17.1	*18.4	14.3	(59.6)△△	41.0	53.0	2nd Out Control *Adjust to 18.4					
JUN.	1952	4.1	18.5	*22.6	12.8	12.8	4.1	18.9	*11.5 + (3x3.7) = 22.6					
JUL.	1952	9.8	11.5	21.3	11.9	24.7	15.6	30.4						
AUG.	1952	9.4	11.5	20.9	11.0	35.7	27.1	41.9						
SEPT.	1952	9.9	11.5	21.4	12.7	48.4	38.6	53.4						
OCT.	1952	8.7	11.5	20.2	13.7	62.1	50.1	64.9						
NOV.	1952	6.5	11.5	18.0	10.2	72.3	61.6	76.4						
DEC.	1952	7.8	11.5	19.3	11.4	83.7	73.1	87.9						

9.4, and a standard error of estimate, σ_d, equal to 3.0.

Table II is the "Control" form in which we depict the "News Reel" of the sales for the current year and the liaison with inventory. In designing Table II we will assume that the sales of Type 560 behave in the current year as they did in the previous year, and accordingly, compute sales capability limits, Col. 7, within which the current sales are expected to be found.

Col. 1. Identifies the 1952 months.

Col. 2. Identifies the net inventory (obtained by subtracting actual sales, Col. 5, from gross inventory, Col. 4.)

Col. 3. Identifies the average predicted shipping increment (the $\bar{X}$ of history values.)

Col. 4. Identifies the gross inventory (net inventory plus shipped.)

Col. 5. Identifies the actual monthly 1952 sales.

Col. 6. Identifies the cumulative actual monthly 1952 sales.

Col. 7. Identifies the capability limits, predicted from the behavior for the previous year, within which current monthly cumulative sales will fall if only random and not systematic influences are present.

The Mechanics of Table II

Using hypothetical values for actual sales for the current year (Col. 5), we will test the validity of the forecast made for the current year from the sales for the previous year. First, we compute current cumulative sales capability limits, Col. 7, for each month of the current year based on behavior for the previous year using $\bar{X} = 9.4$ and $\sigma_d = 3.9$. These limits are set at the 95 percent confidence interval (the cumulative mean $\pm 2\sigma_d$). Secondly, we will protect against maximum limit (at the 99.73 percent confidence interval) for January [$\bar{X} + 3\sigma_d$; i.e., $9.4 + (3 \times 3) = 18.4$] and enter this value in the first row of Col. 4.

With these preliminary entries we are ready to receive the monthly actual sales values, record them in Col. 5, post cumulative sales in Col. 6, and verify the validity of our forecast by checking the cumulative sales value against the maximum and minimum capability limits, Col. 8, for that specific entry. If the cumulative sales entry is outside its capability limits, $\bar{X} \pm 2\sigma_d$, we infer that the sales have sought a new level and our prediction of current sales behavior being the same as for the previous year is invalid. If the cumulative sales value is found within its capability limits, we infer that our sales behavior remains unchanged.

We will note in the case history Table II that the April cumulative sales entry was out of its $2\sigma_d$ capability limits. Inasmuch as there are approximately five chances in 100 of our being wrong by inferring the prediction as invalid at this time, we reduce this probability of error by giving the sales process another opportunity to portray its behavior. The $\pm 2\sigma_d$ used will normally allow values to fall outside its limits by pure chance on the same side of the mean for two consecutive months less than one percent of the time. If the May entry, of the case being studied, is out of its $2\sigma_d$ capability limits, the probability of error in inferring invalid prediction is less than one in 100. Since the May entry is out of its control limits, we assume our prediction is not valid and proceed to find the values of $\bar{X}$ and σ_d of the new sales process.

Referring to Table II, Cols. 1 through 5 and beginning with the 18.4 gross inventory, we note the simplicity of calculation required by various column entries. The ning qualifications required for personnel making these routine entries is of small magnitude.

In Table II, we observe that during the period of January through April when we first noted some anomaly, our shipping increment has been constant. During this interval our net inventory has been decreasing. In order to protect the process against the probability of a "short" gross inventory in May, the May shipment was increased by an amount sufficient to build the May gross inventory back to the January original 18.4. The out-of-control warning in Col. 6 is the signal for net inventory investigation (too large or too small.)

Inasmuch as our forecast for Type 560, Table II, had been found invalid in May of the current year, we proceed to seek this new level and standard error of estimate and predict future behavior on the strength of this new finding.

Where adequate history is not available we find it necessary to investigate all factors that might have contributed to a changed level and temper our inferences accordingly. In our cases, Type 560, we found our estimate of the true new level to be 11.5.

In our studies involving factors of a random nature, we have found orders from a customer varying in size from year to year relative to general business conditions; however, the relationship of the σ_d to the $\bar{X}$ expressed as a percent (the coefficient of variation) is relatively constant, therefore a coefficient of variation $100\sigma_d/\bar{X}$ for a specific class has been used to evaluate the σ_d for a new level. Table II, Type 560, upper right hand corner disclosed an original coefficient of variation $100\sigma_d/\bar{X}$ or $300/9.4 = 31.9$ percent. In determining our new σ_d from the new level 11.5, we find the new σ_d to be 31.9 percent of 11.5, or 3.7.

With a new $\bar{X} = 11.5$ and a new $\sigma_d = 3.7$, we are ready to forecast

the future behavior of Type 560 and proceed to establish new monthly cumulative sales capability limits, Col. 7, using the same procedure as outlined previously.

A study of Table II will reveal cumulative sales values for the balance of the current year within their respective predicted capability limits. The prediction made in June for sales behavior was valid through December. The shipping remained constant at 11.5. The net and gross inventories remained at a satisfactory level.

We have found the accessibility and sensitivity of Col. 7 to be extremely practical. It will be observed that these figures could very well be plotted as a control chart of the type often used with tool wear, fatigue, or changes in viscosity of batch materials where the slope of the central line is often non-zero.

The "control" form, Table II, was designed to display the relationship between sales, gross and net inventory. If we could predict sales, we could set up a predicted "chain" reaction affecting the prediction of inventories, warehousing, transportation, scheduling, production, purchasing, and the multitude of clerical and administrative functions connected with these factors. The procedures for sales forecasting as outlined in this article have reduced biased, opinionated, subjective guessing relative to the moving targets of "ghost" inferences.

References

1. C. A. Bicking, "The Application of Quality Control to Administrative Problems." *Industrial Quality Control*, Vol. VI, No. 6, May 1950, p. 24-25.
2. Frances B. Newman, "A Technique for Adjusting Sales Predictions to Actual Sales Trends: A Method of Inventory Control." *Industrial Quality Control*, Vol. VII, No. 6, May 1951, p. 29.

Quality Control in Paper Finishing

EDWARD R. HOFFMAN*

Hammermill Paper Company

The Problem: To improve and control the perfection of manually counted and sorted paper.

The Process: So that the scope of the problem of defect removal and our approach to it may be appreciated, let us briefly review a few pictures of the process. Paper is made at Hammermill Paper Company complete from log to packed paper. Figure 1 views the process at the end of the paper machine, where a roll is being wound from the continuous web of paper coming from the machine. Here is a unit piece, one roll, containing about 520,000 sq. ft. of paper or 8000 sheets. Since the web from the machine flows out at about 800 ft. per min., it must be stored or wound immediately into roll form. Defective paper as a result of starting a machine or changing grades can be disposed of by discarding parts of rolls formed during this period. Once the paper machine is adjusted and acceptable paper is being made, the operator attempts to prepare rolls of standard diameters. Uniformity of roll diameters is an important requirement in the efficiency and effectiveness of a following stage of manufacture, the sheeting process. Once a roll is partly formed, defects that may now occur cannot be readily seen or removed at 800 ft. per min. from the flow of the process. Following the papermaking stage, the rolls are rewound on a winder to cut them to final size and to remove defects occurring in quantity. This machine is shown in Fig. 2.

Although these winders can be stopped to remove defects, they must also keep up with the paper machine and generally do this by operating up to 3000 ft. per min. Small defects hard to discern cannot be found. After the removal of a quantity defect, the paper is spliced together so as to form a continuous web for subsequent processing. In the paper industry, one must remember that a break in the paper web is just as much of a defect as a wrinkle. Thus, by removing a defect, the splice or sheet end is always left. It is logical then to remove only quantity defects at this point.

In the next stage of the process groups of rolls from one to eight are sheeted at one time. (Figure 3.) Although these machines operate at a moderate speed, the complexity of handling and watching several rolls at a time does not lend itself to good manual defect removal. As the process is now operated, defective webs are interleaved with good paper.

Throughout rewinding and sheeting, defects are flagged with pressure, glued paper markers. The subsequent cutting and trimming of the paper, however, cuts off the projecting end of a marker and/or separates a defect into several sheets, only one of which is marked. Flagging, although it helps in finding defects, is also a defect in itself if the flags are not found at a later point.

In the next stage the paper is manually sorted for defects and counted. Figure 4 shows a detail of the fanning operation, and Fig. 5 the operation of counting. These girls experienced in the art of fanning paper and removing a sequence of

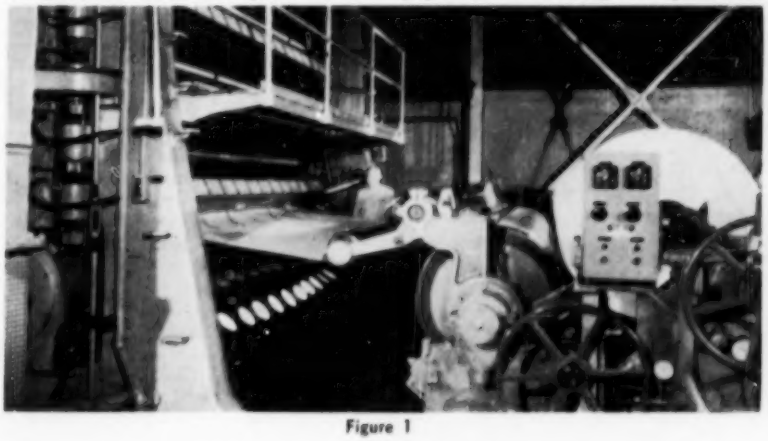

Figure 1

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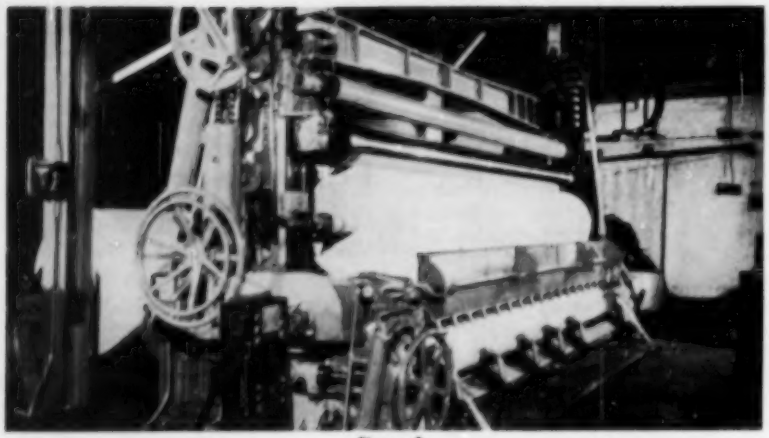

Figure 2

defects, say in every fifth sheet, do a remarkable job. Five hundred sheets, or a ream, is fanned and counted by an operator at the rate of one every 3.3 minutes. This figure includes the normal lost time typical of the operation. In this phase of the finishing operation there are 150 girls preparing 700,000 sheets per day. The girls are grouped into 16 multiple unit crews each under the direction of a forelady. Two such units report to a first-line foreman. Two shift foremen and a superintendent head the organization.

After counting and removal of defects, the paper is trimmed to final size, wrapped and labeled ready for shipment.

The Consideration of the Problem: To control quality in this process additional personnel for inspection purposes is required. It must be added wisely. Two questions can be asked to insure the eventuality of the proper solution. 1. Is the present method of manufacture conducive to good counting and good defect prevention or removal at a reasonable cost? 2. Where can inspection personnel be placed to do the most good in the present method?

With respect to method, let us first consider defects and the possibility of controlling them at the source, say by better maintenance and paper machine manipulation. There is certainly no profit in making a defective product in one operation and discarding it in the next. To obtain better care and use of the paper machines, a measure must first be made of the attributes by machine and crew, so that appropriate repairs can be made and operators more carefully supervised. To gain this end one must sample the process before the identity of the crew who made the paper is lost. This occurs when sheeting five, six or eight rolls at a time on the cutter. Thus the removal of defects somewhere between the paper machine and the cutter would be the ideal area. Removal of defects at the paper machine or rewinders would be thwarted by the rapidity of the process and its continuous nature. Furthermore, removal of a defect at these points is impractical since this leaves a splice or sheet end which in itself is a defect. Also, defects occurring in the sheeting operation, would not be covered. Thus with respect to the identity of the machine and crew, and to the easy removal of defects, the sheeting area is best. Here also speeds are considerably less and the process can be stopped if necessary. The only problem in this operation is to find and remove defects since the paper is already in motion. When we compare the efficiency of this possible method with the present method of hand fanning, requiring multiple units of girls, truckers, equipment and supervision, it is evident that development of a means of finding and removing defects at the cutter is highly desirable. The first recommendation, therefore, is to investigate and promote the possible equipment to remove defects at the cutter. This mechanism should also be arranged so as to count and mark each group of 500 sheets. Furthermore, it should provide the quality control group with a measure of the quantity of defects assignable to the various paper machine crews and machines. This is a long range program designed to improve the process in an economic fashion with the greatest benefits to the consumer and the company. Thus, the control of quality not only involves inspection, control charts and analysis, but it re-

Figure 4

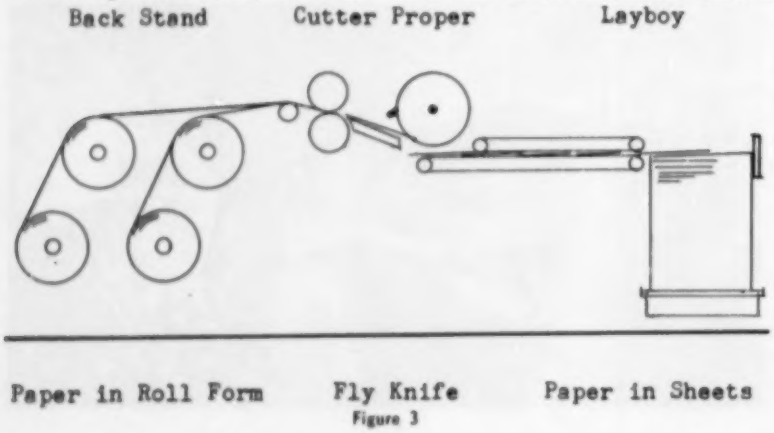

Figure 3

quires consideration of the process so as to make it more susceptible to quality control methods.

Since the process cannot be readily changed as described above, the second question is now ready for consideration. That is, where can inspection personnel be placed in the present process to do the most good? Since defects are removed and the paper counted in the fanning operation, a quality check must follow this operation and fall in the area before wrapping or before the identity of the operator preparing the paper is lost. This requires sampling immediately after trimming and at a point far enough from the operator so that it is difficult for an operator to anticipate an inspection. The longer the time or the number of units on a conveyor between an operator doing a repetitive manual job and the inspection area, the less is the inspection attention necessary to check an operator. This applies, of course, to

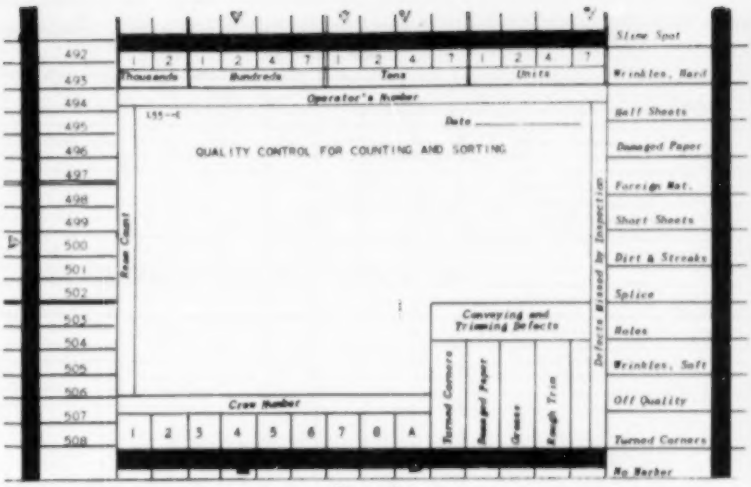

Figure 6

operation and inspection.

Data Handling and Reporting: In this operation of manual counting and sorting, generalized data would

Figure 5

cases where the operator's efforts are not self evident. The number of units on the conveyor between the two points can be counted and the time interval and inspection attention time calculated to keep the operator's risk of inspection as high as possible. With five units or blocks of paper on the conveyor system between the operator and the inspectors, an attention time of 16⅔ percent is sufficient to keep the operator's risk of inspection at 100 percent. One inspector covering eight conveyors could devote 12½ percent of her time to each. A decision was made, therefore, to place one inspector on each shift at a 75 percent operator's risk of inspection rather than put on more inspection than necessary. Once the inspector is assigned and the data are available, a study of the process can be made to get the best balance between the probably not control the quality to the desired degree and therefore requires that each individual girl be repeatedly evaluated for her ability to remove defects and to count. Once this is done then the supervisors of manufacturing could begin to control the operators' efforts. Since two inspectors could readily make 200 inspections per day covering 150 girls, 16 crews, etc., a procedure to analyze and record data had to be developed. A single entry card system was resorted to and a card developed that could be sorted and analyzed readily by hand. If an acceptable gain in quality could be demonstrated, then a commercial system of data analysis might be justified. Figure 6 shows the card developed. On this card the shape of the marginal punch indicates the inspector. Figure 7 shows a group of cards displaced for rapid analysis.

These cards can be rapidly sorted by hand for inspector, for operator by number, by crew and shift. A group of cards may be fanned out as in Fig. 7 and the number of counts at the various values deter-

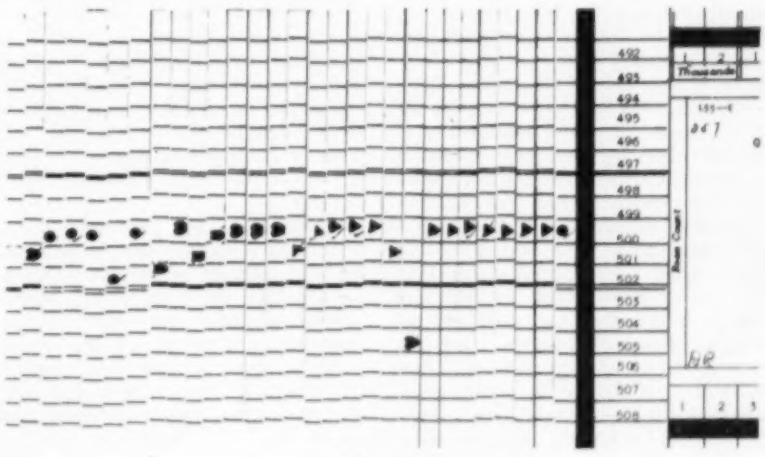

Figure 7

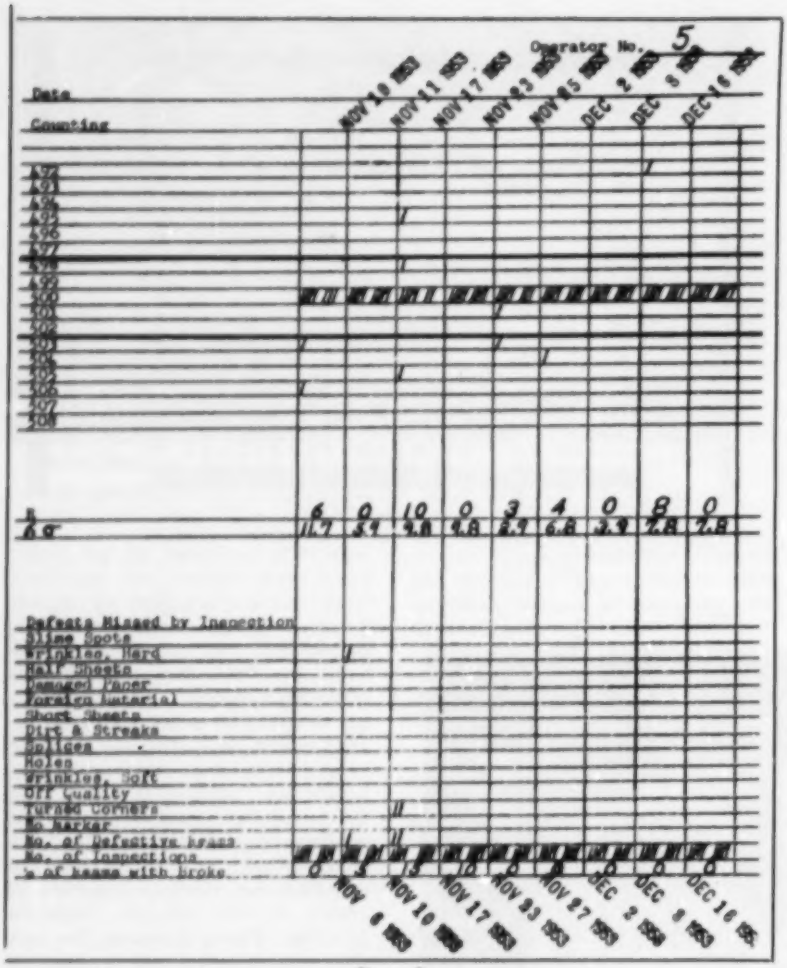

Figure 8

mined. The possibility of rapidly determining the percent miscount, the distribution of count errors or percent defects is obvious. When large groups of cards are to be counted, an electronic counter of the stylus type is used.

Although the 5 x 8 cards may be conveniently accumulated by groups in an ordinary file, it is essential to keep the cards moving through the analysis system so that data are frequently available in all phases. Furthermore, all the raw data had to be made available to the operators and foremen because they were interested and concerned about the records of their efforts. This was accomplished by transferring the data from the cards to a loose-leaf notebook sheet using a form as shown in Fig. 8. One or more sheets as required for each operator are arranged in the notebook in operator number order. At the end of each shift the inspector arranges the inspection cards for the shift in number order by the punch system and transfers the data. Next, the range is calculated for count and the percent defective for defects. The group size is 20 with each group overlapping the previous group by ten observations. Corresponding six sigmas are written in for each group by use of a precalculated table.

Since it is necessary to keep the raw data posted in the Finishing Room, these records are also used to make three month summaries by operator. The summary contains average defective, average count range and percent miscount based on a specification of 500 ± 2. The records of the 150 individuals are kept on 5 x 8 file cards with data listed for each.

Summaries by operators made every three months have been found to be a satisfactory rate at which to accumulate the information. Generally speaking, the values do not fluctuate too much and the trends toward good or poor performance are gradual. One can now very well depend on an operator not to pass more than her established level of defects, nor to exceed her established count range. One other thing is done to keep the individual operator fully informed. That is, "A Notice of Excessive Defects or Miscounts" is issued to anyone exceeding the normal distribution of all operators for a group size of 20 consecutive inspections. On these notices, the total number of notices sent to the individual and the number of consecutive notices prior to the present notice are recorded. This helps supervision to temper its discussions with the individuals.

This covers in detail the analysis of data with respect to the individual operators. Concurrent with this the single entry data cards are moved on through the analysis system.

In the next phase of analysis the cards are accumulated by conveyor in groups of 100 cards. From the groups a calculation and a report of percent defective and percent miscount are made and plotted on control charts. Results are reported at the rate of two conveyor groups per day. General summary control charts are also issued by shift and for the entire operation after each round of charts for all conveyors. All charts are prepared by the quality control group and mailed to the supervising group. On the back of each chart, spaces are provided for issuing date, signature of supervisors and comments. The charts are also returned by mail. With each chart a bar-graph is included giving in detail the breakdown of the defects passed by that group. For purposes of general supervision, control charts are plotted for the various defects based on the entire operation. This gives them the opportunity to know if any one item needs special attention along the line of new instructions or new equipment.

With respect to the data card again, all cards are finally sorted into operator order and filed in boxes by the month. Since each card is signed by the operator at the time of inspection, these serve to verify the inspection and our calculations. Cards are held for three months before discarding.

For the purpose of determining the process average count, range and standard deviation, a sample of 400 cards is drawn at random from the cards accumulated for each month. Through the punch system, the number of counts in each count class is readily determined and from this the distribution of the process. In the case studied the average number of sheets per ream decreased from 501.8 to 500. The high initial count may be contributed to excessive positive

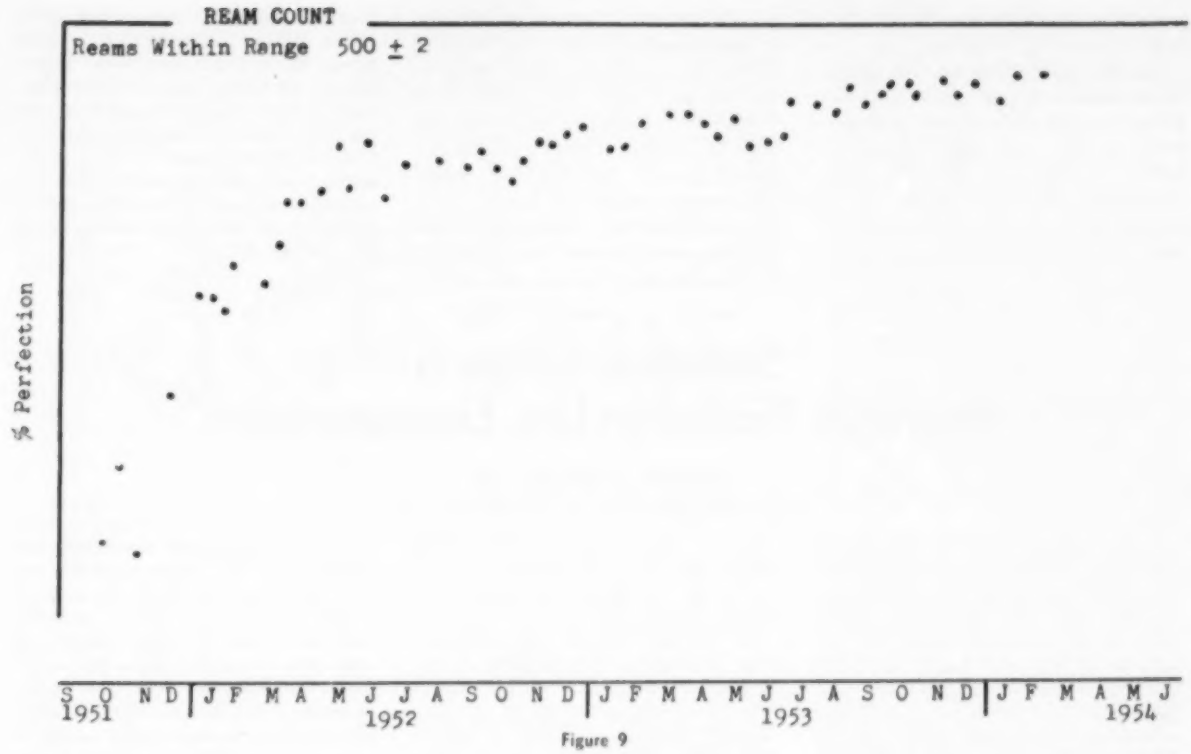

Figure 9

errors and related to the fact that a customer is seldom critical of this kind of defect. The saving in paper has been sufficiently great so as to more than justify the cost of inspection and analysis.

Results: The program accomplished the objective, that is, the improvement of counting and defect removal and has maintained this for a long enough period so as to establish control. Graphically the results may be shown in Fig. 9 and Fig 10. Figure 9 shows the drastic improvement in count and the large percent now falling within ± 2 counts. Figure 10 shows a like improvement with respect to defects with near

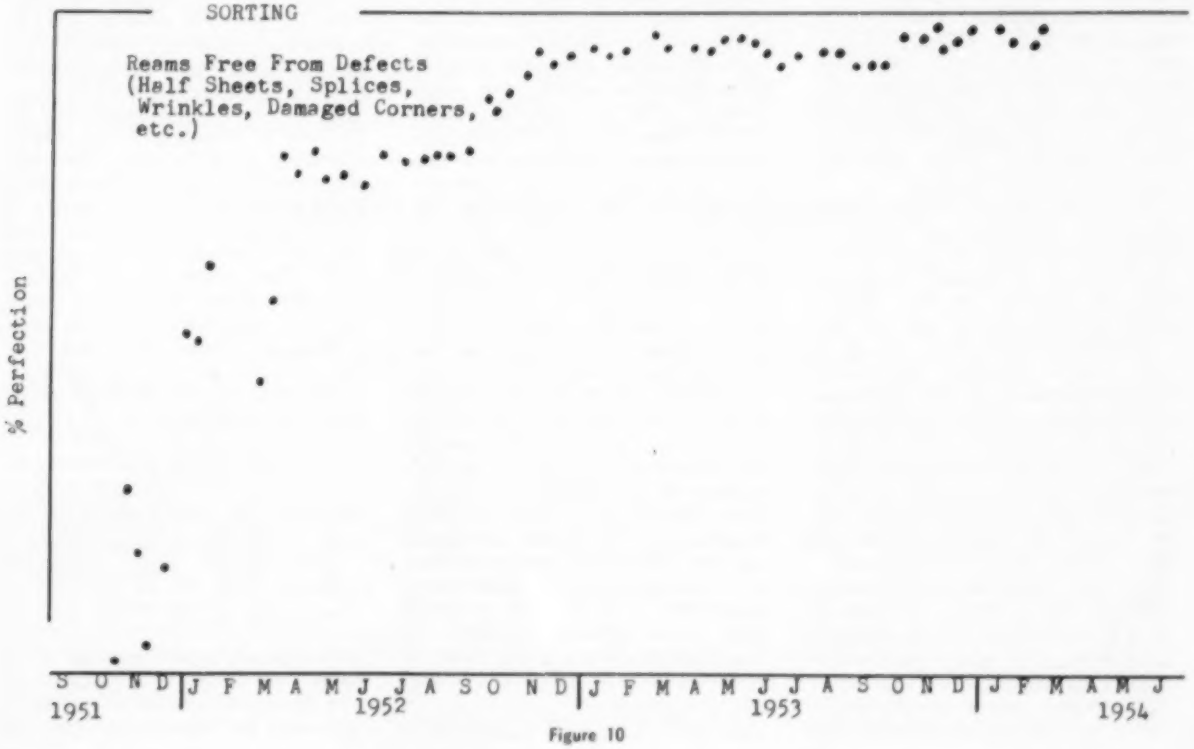
SORTING
Reams Free From Defects
(Half Sheets, Splices,
Wrinkles, Damaged Corners,
etc.)
% Perfection
S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J
1951
1952
1953
1954

Figure 10

perfection for periods as long as ten days frequently occurring.

Besides accomplishing the above improvement, the program also resulted in the delivery of packages more nearly containing 500 sheets with a savings in paper that more than supported the program.

Conclusion: In the application of statistical quality control to an established process, a study of the process is important to determine how it might be changed so as to be susceptible to statistical methods. Too frequently statistical methods are distorted to fit the process. This approach will at least assure a sound long range program.

For the present process it is possible to predetermine inspection attention time so as to keep the operator's risk of inspection at a high level. Such a determination is useful in deciding the minimum required inspection. With minimum inspection, ample analysis made possible through a rapid sorting, single entry punch card system and supervision's cooperation, it is possible to control with assurance a large scale manual operation.

Statistical Design in Electronics Production-Line Experimentation*

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In the manufacture of aluminized television tubes, one of the most important operations is the depositing of a nitrocellulose lacquer film to provide a smooth base for the aluminum mirror. There are several methods for performing this operation, but the one on which the following study was made was a flotation filming process. In this process a quantity of water is added to the bulb after screening; a quantity of nitrocellulose lacquer is then deposited on top of the water and permitted to spread. Afterwards the water is poured out from underneath the film which then adheres to the back of the screen. This type of process has always been characterized by a high average shrinkage rate with large fluctuations between very good results and very high shrinkage. (Shrinkage, in the television industry, means deviating material, including scrap.)

At the time of the initiation of the study, the shrinkage rate was relatively high and the item contributing the most to this high shrinkage rate was "holes in the film." Under these circumstances it was felt that a statistical investigation would be very useful. Normal engineering and production approaches had been found incapable of permanently solving the problem. This was because of the existence of a large number of possible causes for holes, the relative importance of which was not known. In addition, it was felt that it was quite possible that there were significant interactions on several of these sources of variation, thus complicating the problem a great deal. The adoption of a statistical approach to the solution to this problem would result in the greatest economy of experimentation, and also should eliminate the bias of persons who had been working on the problem, "pet ideas", and things of that nature.

It was felt that the experimentation should be performed in the production operation, since duplication of all the conditions of the production processes would be almost impossible on a laboratory scale. The first step in the experimental procedure was to institute a preliminary survey. This was followed through in an orderly fashion, starting with observation of the procedures in use, and checking these against established published methods to determine whether or not there were any important variations. Then discussions were held with the production supervision, the engineers involved, planners, the operators, machine attendants, the maintenance people, and everyone else who might have any ideas concerning the possible sources of the difficulty. As a result of these discussions, the list of all factors which might possibly cause variation, in the opinion of any of the people who were talked to, reached a total of 40. Some of these were obvious from the beginning, and some were not. A few of them were items which could not be controlled by any experiment or by anyone working on the process, except possibly by very expensive installations of equipment. Most of these, however, could be measured even though they could not be controlled. Other factors could be controlled but not measured. And a third group could be both measured and controlled. It was from this third group that the factors were to be selected for study.

*Presented at the 8th Annual Convention, ASQC, St. Louis, Missouri, June 10, 1954.

The first group chosen were those which had been mentioned as possible sources of holes by the greatest number of people interviewed. At this time control charts and special shrinkage records were set up to give the picture over the entire course of the investigation showing what improvements were made. It was decided that two experiments could be run simultaneously, each comparing three levels of four variables. In order to have a reasonable estimate of error, the first Graeco-Latin square was replicated three times; the second, four times. The variable measured to give the estimate of resultant quality was an arbitrary score based upon the diameter of the hole and the quantity of holes of each size recorded.

In the first experiment all four sources of variation were determined to be significant. However, one was significant far beyond the limits of the table, one significant at the 0.1 percent level, and the other two significant at the five percent level. This is illustrated in Table I. In each case we were able to reject one level and have relatively little preference between the other two. This gave us an area in which we could work without too much variation in the end result.

TABLE I—Summary of Variance—Experiment I

SOURCE	SS	DF	MS	"F" RATIO
A	31 939	2	15 970	4.97*
D	132 739	2	66 370	20.67****
G	36 141	2	18 070	5.63*
K	68 091	2	34 046	10.60***
Residual	57 803	18	3 211	
Total	326 713	26		

The second experiment, run at the same time as the first, yielded only one significant source of variation, as noted in Table II. In this one

also there was a rejection of one level with relatively little choice between the two remaining.

The third experiment was a Latin square design with just three factors, each at three levels, one of them repeated from Experiment I to verify some rather unexpected results which were obtained in this experiment. For the same reason as in Experiments I and II, the design was replicated four times. However,

TABLE II—Summary of Variance—Experiment II

SOURCE	SS	DF	MS	"F" RATIO
N	4 006	2	2 003	5.08*
Q	367	2	184	
T	434	2	217	
W	747	2	374	
Residual	10 644	27	394	
Total	16 198	35		

one of the pieces of data was lost—thus reducing the total number of degrees of freedom available by one, as shown in Table III. Table III shows the result of this analysis. All three factors were significant, one at the one percent level, the others beyond the limits of the table. This clarified the effect of the variable carried over from the first experiment and gave us a choice of one particular level of each of the three factors involved.

TABLE III—Summary of Variance—Experiment III

SOURCE	SS	DF	MS	"F" RATIO
α	211 739	2	105 870	33.22****
δ	122 980	2	61 490	19.29****
G	53 100	2	26 550	8.33**
Residual	89 235	28	3 187	
Total	477 054	34		

At the same time we ran Experiment IV, which was a full factorial design of two variables, each at three levels, replicated three times. The full design was chosen because of the high degree of possibility of the existence of a significant interaction between the two factors chosen. As the analysis in Table IV shows, however, this interaction did not prove to be significant, and only one of the main effects was a significant source of variation. This gave us a definite choice of one level of this factor and a rejection of the other two.

TABLE IV—Summary of Variance—Experiment IV

SOURCE	SS	DF	MS	"F" RATIO
θ	5 745	2	2 872	
λ	198 690	2	99 345	22.83****
$\theta \times \lambda$	26 055	4	6 514	1.68
Residual	69 672	18	3 871	
			(4351)	
Total	300 162	26		

Experiments III and IV were run under controlled conditions at the best levels of the factors that had been studied in Experiments I and II. This resulted in such a great improvement in the holes found during this investigation that it made analysis rather difficult. Therefore, at this point it was decided to issue a report informing the factory of the advances made to date and permitting them to incorporate these improvements in their process. This was done with a marked reduction in shrinkage attributable to holes.

TABLE V—Summary of Variance—Experiment V

Source	SS	DF	MS	"F" Ratio
λ	505	2	252	1.98
δ'	93	2	46	
θ'	510	2	255	2.00
Residual	3 700	29	127.5	
Total	4 808	35		

Experiments V and VI were then run, partially to verify the results found previously and partially to extend the areas investigated on certain significant variables. This permitted us to optimize the process, giving the best possible results obtainable with the materials we were using. Experiment V was a 3×3 Latin square replicated four times. It yielded no new information on holes. This is illustrated in Table V.

TABLE VI—Summary of Variance—Experiment VI

SOURCE	SS	DF	MS	"F" Ratio
	For Holes			
A'	2 639	3	879	
π	989	3	329	
α'	7 477	3	2 492	2.54 (9%)
Residual	37 228	38	980	
Total	48 333	47		
	For Other Defects			
A'	51	3	17	4.15**
π	182	3	60.7	14.80****
α'	175	3	58.3	14.22****
Residual	157	38	4.1	
Total	565	47		

Table VI also shows no new information concerning holes; but anticipating this, we designed it to give significant information about some of the other defects noted in the filming operation. This was a thrice-replicated 4×4 Latin square, again intended to permit us to optimize the process. This was quite successful and yielded an optimized process which has proved to be quite workable. Holes have been reduced as a source of shrinkage by more than 50 percent, even though some of the expensive work involving large equipment installations has not yet been undertaken. The stability of the overall process has also been greatly improved.

Statistical Design of Experiments in Metallurgical Research

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The Need for Statistical Design

It has been stated by R. A. Fisher,[1] "Critics who refuse to accept the conclusions supposedly proved by experimental evidence are accustomed to take one of two lines of attack. Claims may be made that the interpretation of the experimental data is faulty. Such criticisms of interpretation are usually treated as falling within the domain of statistics. However, aside from the responsibility of the statistician to understand the processes he applies or recommends, the basic understanding of scientific inference is the obligation of all concerned with the experiment."

A second type of criticism to which experimental results are exposed is that the experiment itself was poorly designed. Many research programs from which decisive conclusions have been drawn were based on high-powered interpretations of very meager data. The essential point made by Fisher is that both types of criticism are aimed at different aspects of the same thing. If the design of an experiment is faulty, any method of interpretation which makes it out to be decisive must be faulty, too. Statistical analysis of data and experimental design are two different aspects of the same requirements for successful experimentation.

The processes by which steel is manufactured and fabricated lend themselves readily to the application of certain statistical techniques in analyzing the problems presented to the Applied Research Laboratory. Whether in estimating the average particle-size distribution of a par-

ticular grade of iron ore from the Mesabi Range, or in determining the long-term corrosion of piling in sea water, certain observations of these phenomena must be made before they can be evaluated. The line of attack that a research worker generally follows in evaluating a given process is to formulate hypotheses about the process, and then to proceed to disprove or verify these hypotheses in the light of the observational data that he has collected. The purpose of experimental design is to ensure that the experimenter obtains adequate data relevant, to his hypotheses in as economical and efficient a way as possible. It is in this phase of experimentation that the statistician can make a major contribution to the research worker.

Classification of Experiments

Experimentation may be divided into two broad subclasses: absolute and comparative. An absolute experiment is one in which the exact value of some measurable quantity is to be determined. An example of this type of experiment in the steel industry would be the determination of the average particle-size distribution of a particular grade of iron ore shipped to a blast furnace. A comparative experiment is one in which two or more treatments are compared in their effects on a chosen characteristic of a population. If an experiment is conducted to determine the effect of two different types of ore on the iron production of a blast furnace, we say that a comparative experiment is being run.

Experimentation in the laboratory, where the observations are made with control effected by the experimenter fixing the levels of the variables, or by statistical control effected by randomization, is generally of the comparative type. However, in conducting a sample survey in the field, as is often done, the concepts of absolute experimentation are abandoned when the experimenter finds that to fix the value of some quantity, such as the average size-consist of a grade of iron ore, he must first investigate the importance of the factors that influence the size of the ore as it comes to the blast furnace. This leads him into a comparative study, even though he cannot control the variables affecting the quantity he is observing. An example of an uncontrolled comparative study occurred when the Applied Research Laboratory undertook to estimate the degradation of iron ore being shipped from the mines in Minnesota to the blast furnaces in the Pittsburgh area.

The problem was to determine the degradation, or breaking up, of the ore due to handling in shipment. Samples of the ore were obtained from the screening plant located at the mines in Minnesota, and from the bins adjacent to the blast furnaces in Pittsburgh. In between the two sampling locations, the handling of the ore could not be controlled by the men conducting the test. It was handled in a standard manner representative of all ore shipments. A number of samples, from which an estimate of the average size-consist could be derived, were obtained at each sampling area.

The measurement data obtained in this sampling program enabled the experimenters to evaluate the magnitude of the ore degradation between the point of shipment and the point of actual use. The estimate of the average difference in size-consist between these two points, and the statistical uncertainty associated with estimating this average difference, were then used in determining the optimum location of a particular ore-treating plant.

More frequently, however, the experiments conducted at the Applied Research Laboratory are of the controlled comparative type. In these test programs the application of statistical design to the problem has led to more efficient collection and analytical use of test data, and to greater validity of the conclusions drawn from them.

Factorial Designs: Full Replicates

Frequently the experimenter is faced with the problem of determining the effect that the variation of several factors will produce on a particular process. To facilitate efficient experimentation, two concepts of experimental design are introduced into the plan: multiple balance of experimental conditions, and randomization of experimental trials. First, the concept of multiple balance of experimental conditions, introduced by R. A. Fisher, is employed. Its application is illustrated in an experiment involving the evaluation of the effects of two variables, call them A and B, on a particular physical property of steel. The classical and now outdated concept of varying only one factor at a time and comparing its result with that of the control level, would lead to an inefficient estimation of the effects of the variables on the quantity being measured.

The factors, A and B, are to be studied at two levels. The lower level of each factor can be denoted by zero and the upper level by one. To investigate these factors at the two levels in the classical manner would require making only three runs. The three runs and the level of each factor in the runs are shown in Table I.

TABLE I

Factor	A	B
Run 1	0	0
Run 2	1	0
Run 3	0	1

The three runs in Table I will suffice to determine the effect produced either by changing factor A from its lower level to its higher level, or by varying factor B. This is accomplished by comparing Run 1 with 2 and Run 1 with 3, respectively. However, these three runs are unbalanced in two respects. Of the six factor levels, four are at the lower level and two are at the higher level. For each comparison the control run, Run 1, is used to make a judgment of the effect produced by varying the levels of A and B. Furthermore, these runs furnish no information on the effect produced by factors A and B both being present at the upper level. It is also conceivable that the effect produced by changing the levels of factor A from low to high would not necessarily be the same at both levels of factor B. This is known as "interaction," which can be defined as the failure of one variable to produce the same magnitude of effect at all levels of another variable. At times the evaluation of the interaction term of an experiment is of more interest than the determination of main effects. Consequently, when the existence of an interaction is likely in an experiment, the experimental design must be constructed to enable determination of this interaction.

The set of runs in Table II will enable the experimenter to evaluate the main effects of factors A and B, and the A x B interaction for this program.

TABLE II

Factor	A	B
Run 1	0	0
Run 2	0	1
Run 3	1	0
Run 4	1	1

A comparison of this set of four runs with the set outlined in Table I

shows several advantages. First, the statements made concerning the effects of varying factors A and B are more precise. In the design proposed in Table II the main effects are obtained by comparing the two runs made at the lower level of the factor with the two runs made at the higher level. Thus all four runs are used to measure each main effect, by this means as much precision being attained in each conclusion as if all four runs were devoted solely to the measurement of a single factor. The A x B interaction is determined from a comparison of the difference in results of Runs 1 and 4, with the difference in results of Runs 2 and 3. All four runs have also been used in determining this relationship. Thus from four runs three conclusions have been derived, each conclusion being based on experimental evidence supplied by all four runs.

The two-factor experiment described above is the simplest case of an experimental plan known as the factorial design. The interaction is the important effect about which the factorial design can give information. However, even in the analysis of a problem where it is known that an interaction is nonexistent, the factorial design does not lose any information. If it can be assumed beforehand that the interaction of factors A and B is nonexistent in the design laid out in Table II, this design still furnishes more information about the main effects produced by the two factors. The average difference between the two levels of factor A is obtained from two individual differences, and likewise for the average difference between the two levels of factor B. Thus, in the absence of an interaction, the factorial design furnishes a certain amount of "hidden replication," or duplication, depending upon the number of factors being investigated.

After completion of the program to determine the effects produced by factors A and B, it was thought that a third factor, C, might have some effect on the property being determined. It could not be assumed that the effect of factor C would be entirely additive, that is, would not interact with the two other factors. An expansion of three factors each studied at two levels required that eight runs be made for a fully balanced array. These eight runs would furnish sufficient information to arrive at seven conclusions on the effects produced by the variation of three factors. Of these seven conclusions three would be on the main effects of the factors A, B, and C; three on the failure of each of the single factors to produce the same effect at both levels of another factor (first order interactions); and one on the failure of the A x B interaction to be different at the two levels of factor C. This would be the A x B x C interaction. The same quantity also measures the difference of the A x C interactions at the two levels of B, and similarly for the B x C interaction. An interaction of three factors such as this is termed one of the second order.

The factor levels of the eight runs to be made are given in Table III.

TABLE III

Factors	A	B	C
Run 1	0	0	0
Run 2	0	1	0
Run 3	1	0	0
Run 4	1	1	0
Run 5	0	0	1
Run 6	0	1	1
Run 7	1	0	1
Run 8	1	1	1

Close examination of the factor levels of the eight runs reveals that the makeup of the first four runs in this set, with the exception of the added C factor, is identical with the four runs listed in Table II. Consequently two possibilities were open to the experimenter at this point. If the first four runs, which were made to evaluate the effects produced by factors A and B, were free of any systematic bias (for example, the effect of seasonal variation affecting the quality of raw materials entering the process, or any other nonrandom fluctuations occurring over the time interval between the completion of the first experiment and the running of the second,) then in the investigation of the effect of the third factor, the data from the first four runs with C at its lower level, as in Table II, could be used in conjunction with Runs 5 through 8. If, on the other hand, a systematic bias due to the time interval between experiments was suspected, then, to arrive at an unbiased estimate of the effects produced by the three factors, the full set of eight runs in Table III would have to be made. In addition, if a trend due to the order in which these eight runs are made is likely, then a random sequence of making the runs must be chosen to minimize the associated time effect. This second important aspect of experimental design—the concept of randomization of experimental trials—is too often passed over lightly by the experimenter. An attempt should be made to randomize all experimental conditions that are not under the control of the experimenter but that might produce an effect on the quantity being measured. The simple precaution of randomization guarantees the validity of the test of significance by which the result of the experiment is to be judged. It is not in the scope of this article to offer more than a brief reference to this important concept.

The number of runs required by any factorial design can be determined by the simple expansion of a term, p^n, where n represents the number of factors being varied and p denotes the number of levels at which each of these factors are to be studied. For simplicity, the cases dealt with thus far have been restricted to two levels. However, the general factorial design is not restricted to the investigation of two-level factors only. The theory, construction, and practical examples of factorial designs of a more complex nature are well covered in all the references appended to this article.

Factorial Designs: Fractional Replicates

The relative complexity of some of the processes being evaluated at the Applied Research Laboratory is such that the fulfillment of the concept of balance, given by the factorial design, leads to the making of far too many experimental runs. In an experiment to evaluate the effects of eight factors, each being varied over two levels, a total of 256 runs would have to be made. Even with the very simplest experimental device for making these runs, the experimenter will often balk at making such a prodigious number of tests. From an economic and practical viewpoint, it is sometimes virtually impossible to test the number of treatment combinations imposed by the use of the complete factorial design of experiment. Furthermore, when the number of factors is greater than five or six, the great majority of the information furnished by the factorial design relates to high-order interactions, which are unlikely to be either real or of interest.

In an experiment involving the evaluation of the effects produced by eight factors at two levels each, it was reasonable to assume that the experimental error was small and that the high-order interactions involving four or more factors were

negligible. The pooling of these high-order interactions, which account for 163 out of the possible 255 degrees of freedom for this experiment, furnished a well estimated term for use in judging the significance of the effects that were to be evaluated. When experimental error is small and the high-order interactions are not of appreciable magnitude, the precision furnished by the complete factorial design is unnecessary. It is possible to carry out only a fraction of these large factorial experiments and still retain satisfactory information on the main effects and lower-order interactions. The problem confronting the experimenter is which of the total number of runs for the full factorial shall be included in the partial or fractional factorial set to be run.

The answer to experimental situations of this kind involves the use of "Fractional Replicate Designs." This type of design was first reported by Finney[2,3]. The construction of these designs is well covered in statistical texts by Brownlee[4], Kempthorne[5], and Cochran and Cox[6]. An article by K. A. Brownlee, B. K. Kelly, and P. K. Loraine[7] presents a method for constructing fractional designs having as many as 512 runs. For the industrial research worker who cares little about the mathematical background of these designs, the article by O. L. Davies and W. A. Hay[8] is a good introductory work in the construction and uses of fractional factorial designs. It is not within the scope of this article to present the underlying assumptions and theory of the fractional replicate design. Instead, the utility of the method will be illustrated by an example of its application to an industrial research problem.

A program was initiated at the Applied Research Laboratory to study the effects of some of the operating variables that influence the performance of an open-hearth furnace. The test program was to be carried out on a pilot-plant level in a model furnace of the same design as a full-scale operating open hearth. Since the primary purpose of the study was to determine the "firing" characteristics of this particular furnace design, it was not necessary to actually melt and refine steel in the model. Instead, a complete thermal instrumentation of the model furnace was made. The instrumentation permitted the measuring and recording of such things as fuel rate, air rate, Btu to the hearth, and Btu lost in the waste gases, all of which affect the efficiency of an open-hearth furnace. The furnace was also instrumented for the precise control of the experimental conditions of operation whose effects were to be evaluated. Although the physical equipment necessary for running the test was available, the proper experimentation for its most efficient use had to be designed.

Eight operating variables, which were thought to be of primary importance to the efficient firing of an open hearth, were chosen to be studied at each of two operating levels. Each variable is called a factor and the various states or conditions of that factor are called its levels. For example, furnace pressure would be a factor and the actual pressures used would be the levels of that factor. The factors chosen must be capable of being varied over the levels independently of the levels of the other factors in a particular experimental run. Since the aim of this example is to illustrate a method rather than to report specific information on the firing of an open hearth, it will suffice to refer to the eight factors being studied as A, B, C, D, E, F, G, and H. Similarly the actual operating levels of these factors can be denoted by a zero for the lower level, and a one for the upper level of a particular factor.

The full investigation of the effects produced by the variation of eight factors from one level to another, in the context of all possible combinations of the other seven, would require making 2^8 or 256 runs. To make this many runs, involving both time and materials, would be uneconomical, impractical, and, as will be shown, unnecessary for the scope of this program.

From previous information on the behavior of the model furnace, it was concluded that the experimental error associated with the measurements made was not appreciable. Furthermore, it could reasonably be assumed that the magnitude of the high-order interactions would be small, and that only a vague meaning could be attached to them. On the basis of these assumptions, a balanced selection of a fraction of the total number of runs required by a full factorial design could be made. It was arbitrarily agreed that 64 runs could efficiently be made; this number of runs would furnish information on each of the eight main effects and each of the 28 first-order interactions. In making only 64 runs out of a total of 256 required by the full factorial, the amount of experimentation was reduced by 75 percent, the price being paid for this reduction being the inability to estimate the effects of the higher-order interactions. The 64 experimental runs with the levels of each of the eight factors for the runs are outlined in Table IV.

The number of runs to be made constituted a ¼ replicate of a 2^8 factorial design. The job of choosing the particular 64 runs out of the possible 256 has been simplified by the work of Brownlee, Kelly, and Loraine.[7] The information summarized in Table 3 of their article was used to lay out the fractional replicate for this investigation.

Inspection of the makeup of the runs in Table IV reveals the intri-

TABLE IV

Run	FACTOR A	B	C	D	E	F	G	H	Run	FACTOR A	B	C	D	E	F	G	H
1	1	1	1	1	0	1	1	0	33	0	1	1	1	1	1	1	1
2	1	1	1	1	0	1	0	1	34	0	1	1	1	1	1	0	0
3	1	1	1	1	0	0	1	1	35	0	1	1	1	1	0	1	0
4	1	1	1	1	0	0	0	0	36	0	1	1	1	1	0	0	1
5	1	1	1	0	1	1	1	0	37	0	1	1	0	0	1	1	1
6	1	1	1	0	1	1	0	1	38	0	1	1	0	0	1	0	0
7	1	1	1	0	1	0	1	1	39	0	1	1	0	0	0	1	0
8	1	1	1	0	1	0	0	0	40	0	1	1	0	0	0	0	1
9	1	1	0	1	1	1	1	0	41	0	1	0	1	0	1	1	1
10	1	1	0	1	1	1	0	1	42	0	1	0	1	0	1	0	0
11	1	1	0	1	1	0	1	1	43	0	1	0	1	0	0	1	0
12	1	1	0	1	1	0	0	0	44	0	1	0	1	0	0	0	1
13	1	1	0	0	0	1	1	0	45	0	1	0	0	1	1	1	1
14	1	1	0	0	0	1	0	1	46	0	1	0	0	1	1	0	0
15	1	1	0	0	0	0	1	1	47	0	1	0	0	1	0	1	0
16	1	1	0	0	0	0	0	0	48	0	1	0	0	1	0	0	1
17	1	0	1	1	1	1	1	1	49	0	0	1	1	0	1	1	0
18	1	0	1	1	1	1	0	0	50	0	0	1	1	0	1	0	1
19	1	0	1	1	1	0	1	0	51	0	0	1	1	0	0	1	1
20	1	0	1	1	1	0	0	1	52	0	0	1	1	0	0	0	0
21	1	0	1	0	0	1	1	1	53	0	0	1	0	1	1	1	0
22	1	0	1	0	0	1	0	0	54	0	0	1	0	1	1	0	1
23	1	0	1	0	0	0	1	0	55	0	0	1	0	1	0	1	1
24	1	0	1	0	0	0	0	1	56	0	0	1	0	1	0	0	0
25	1	0	0	1	0	1	1	1	57	0	0	0	1	1	1	1	0
26	1	0	0	1	0	1	0	0	58	0	0	0	1	1	1	0	1
27	1	0	0	1	0	0	1	0	59	0	0	0	1	1	0	1	1
28	1	0	0	1	0	0	0	1	60	0	0	0	1	1	0	0	0
29	1	0	0	0	1	1	1	1	61	0	0	0	0	0	1	1	0
30	1	0	0	0	1	1	0	0	62	0	0	0	0	0	1	0	1
31	1	0	0	0	1	0	1	0	63	0	0	0	0	0	0	1	1
32	1	0	0	0	1	0	0	1	64	0	0	0	0	0	0	0	0

cate balance of treatments resulting from the particular quarter fraction chosen to be made. There are 32 zeroes and 32 ones in each column; that is, each factor was investigated at its lower and upper levels in an equal number of runs. For any set of 32 zeroes, (or ones), there are 16 zeroes and 16 ones in each of the other columns, but always a different split for each pair of columns. The requirement of maintaining a balance of experimental conditions for efficient use of all the data collected in an investigation is accomplished with the fractional replicate design. The balance of experimental conditions furnishes information on the effect of each factor in a variety of contexts, permitting a more general use of the results. Furthermore, the balanced set of experiments, particularly when dealing with two-level factors, affords an easy analysis of the resulting data.

It has been shown previously in this article that for any two factors, call them P and Q, three conclusions may be obtained from four balanced runs. If the experimental conditions for the four runs are P_0Q_0, P_0Q_1, P_1Q_0, and P_1Q_1, the three conclusions may be obtained by putting the four values for the runs in a "2 x 2" table, as follows:

		P	
		0	1
Q	0	P_0Q_0	P_1Q_0
	1	P_0Q_1	P_1Q_1

The effect of changing the level of factor P from its low to its high level is given by the difference in the column averages. The effect of changing from Q_0 to Q_1 is given by the difference in the row averages. The P x Q interaction, which measures the failure of the effect of P to be the same at the two levels of Q, is given by the difference between the two diagonal averages. These three effects are independent, even though each conclusion uses all four results. The expansion from two factors to eight factors does not lead to a more complex analytical solution of the data.

The 36 conclusions (eight main effects and 28 first-order interactions) for the open-hearth program are obtained by putting the data into the appropriate four cells in 28 such "2 x 2" tables. Each of the four cells in any two-way table will contain the average of the 16 runs made which fit the cell specification. For example, two of the factors studied were Fuel Temperature and Steam Pressure. Of the 64 runs made, 32 were made with a low fuel temperature and 32 with a higher fuel temperature. Of the 32 runs at a low fuel temperature, half were made at a low steam pressure and half at a higher steam pressure. The same pattern of symmetry existed for the 32 runs made at the high fuel temperature. To estimate the effects of varying the fuel temperature and fuel pressure on the Btu's transmitted to the hearth, the data were entered in the following table*:

TABLE V

		Fuel Temperature Low	High	Avg.
Steam Pressure	Low	40	80	60
	High	24	60	42
	Average	32	70	

Each number in the body of the table represents the average of all the data for 16 runs. The row and column averages represent the data from 32 runs each. The overall difference between column averages indicates an increase in Btu's to the hearth when the fuel temperature is increased from its low to its higher level. Similarly, there is an indication of a decrease in Btu's to the hearth when the steam pressure is increased in the range specified by the low and high levels of this factor. The increase in Btu's to the hearth with increasing fuel temperature is somewhat greater at low steam pressure than at high steam pressure. The measure of this failure of the fuel-temperature change to produce the same effect at low and high steam pressure is obtained by comparing the difference between the two increases just mentioned. A similar analysis is made for each of the 27 remaining two-way tables. All the measured data from the 64 runs is used in drawing each conclusion on the main effects and interactions for this investigation. Furthermore, only 36 (eight main effects and 28 first-order interactions of one degree of freedom each) of the total of 63 degrees of freedom for the experiment have been used in obtaining the desired information. This leaves 27 degrees of freedom for estimating the "residual error" term to be used in making significance judgments. The information on the residual error can be used in calculating "confidence intervals" for estimating the average difference produced by changing the levels of a factor[4]. In making these 64 runs, more information has been furnished on the behavior of the eight factors than could have been obtained by a far greater number of actual runs taken just as they occurred in practice.

*The data in this table are not indicative of actual operating data and no significance should be attributed to the trends indicated.

The particular fractional replicate design described is only one of several that could have been used to evaluate the effects produced by the variation of the eight factors. This application was chosen because of the simplicity of the design. It is not implied that all fractional replicate designs can be applied as easily as this. The use of a fractional design permits the experimenter to investigate the behavior of a number of factors, even though the number of experiments that he can run is limited. This concept of experimental design can be a very valuable tool in evaluating the complex processes that occur in industrial research. The choice of a fractional design does, however, require considerable care, and the experimenter would be unwise to use this type of design at any available opportunity without first examining all the facets. The fractional replicate design furnishes an experimental program for evaluation of main effects and low-order interactions with a precision of results impossible to attain by any other method. If the factors chosen to be studied are the decisive ones, this design enables their evaluation to be made with a minimum of time involved in experimentation. However, the fractionally designed experiment is very sensitive to missing data and therefore, the interpretation of results cannot be achieved until all the runs have been completed and all the data have been collected. A study of the references given previously will provide a more detailed coverage of the concepts of fractional replication with practical examples of its use in industry and research.

Planning for Efficient Experimentation

In both types of experimental design discussed in this article, the concepts of balance and randomization of experimental conditions have been shown to be fundamental in enabling the experimenter to draw valid conclusions from his experimental data. Neither of these statistical principles for experiments can be applied without the appropriate forethought and planning. They can almost never be superimposed on a mass of data resulting from a number of experiments not previously designed to answer specific questions.

Too often the experimenter seeks the advice of a statistician in making inferences from the results of experiments. Since the inferences that can be made depend on the way in which the experiment was carried out, the statistician can only rarely guarantee a successful interpretation of data gathered without statistical plan. It sometimes occurs that no inferences can be made, or that those which can be made do not answer the questions to which the experimenter had hoped to find answers. The statistician can only indicate how to avoid these outcomes in future experiments. As a result of such unhappy circumstances, it has come to be realized that the time to think about statistical inference, or to seek advice of the statistician, is during the planning of the experiment.

Generally, too little time and effort is devoted to the planning of an experiment. Experimentation is both costly and time consuming. Therefore, it behooves the research worker to consider an intensive planning period prior to the actual performance of the experimental work. It is a good practice to make a written draft of the proposals for any experiment. In a recent article by C. A. Bicking[9], a detailed "check list" for planning test programs was presented. Adherence to a check list, of which the experimental design is a vital part, guarantees the performance of an efficient experimental program to furnish data relevant to the objectives under consideration.

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Statistical Principles of Testing

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ABSTRACT

The answer to many problems in science, both fundamental and applied, is found in small differences in the numerical values of a few measurements. In determining these differences, it is necessary to guard against biases introduced by the testing procedure. One of the principal functions of statistical design is to detect and neutralize these biases.

The examples briefly described to illustrate this approach involve a study of homogeneity of a polyisobutylene sample, a road test of automobile tires to determine rate of treadwear, and an interlaboratory study of the aging characteristics of natural and synthetic rubbers.

Introduction

In discussing an old experiment, one that was carried out by Lavoisier about 1770 in order to demonstrate the role of air in combustion, Professor James B. Conant[1] speculates on the fact that sulphur and phosphorus were used in this experiment, rather than metals. One of the things pointed out by Conant is that the combustion of the common metals, such as tin, results in a relatively small weight increase, so that with the experimental techniques available in the 18th century, its very detection might well have been a difficult task. Boyle had carried out such experiments, concerning which Conant adds:

"It is therefore not surprising that the glass retort, after heating, varied in weight from day-to-day almost as much as the total gain in weight in one of the two experiments."

It is worth noting that, in Conant's opinion, the answer to one of the most fundamental questions in early scientific history, the validity of the phlogiston theory, thus became dependent on the existence or nonexistence of a small increase in a measured quantity.

Since the days of Lavoisier, spectacular progress has been made in the precision of measurements, but the answer to many problems, both fundamental and applied, is still to be found, on final analysis, in small

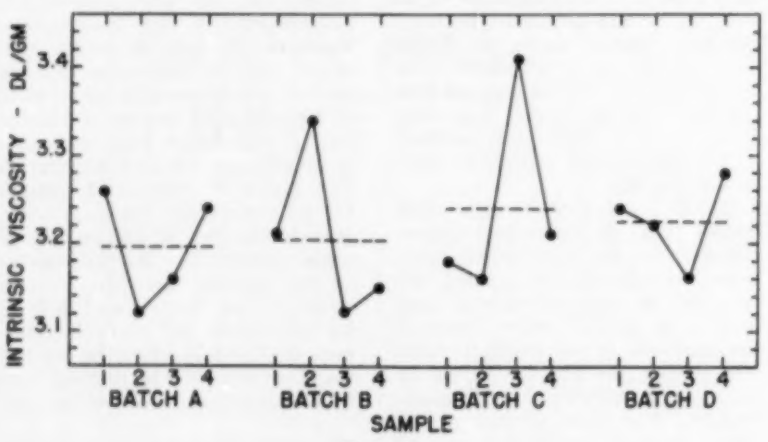

Figure 1

differences in the numerical results of measurement. It is in problems such as these that statistics has become a valuable tool for the experimental scientist.

Much has been said and written about the contrast between the classical approach to experimentation and the so-called statistical or factorial approach. The usefulness of statistics in experimental work is, however, not confined to the idea of varying several factors simultaneously. Perhaps the most fundamental aspect of the statistical approach in experimentation and testing is its preoccupation with errors of all kinds: errors of sampling, systematic errors, random errors, and many others. For the reassurance of experimenters who may consider this as a somewhat neurotic, or at best, highly pessimistic viewpoint, it should be stated that the statistician's objective, in considering errors, is to do something constructive about them.

The Role of Statistics

A few examples may help in presenting this conception of the role of statistics in physical and chemical experimentation.

1. Recently, samples of polyisobutylene were prepared for a study of dynamic tests to be conducted in laboratories in this country and abroad. We are concerned here only with the question of homogeneity of the polyisobutylene with regard to average molecular weight. To test for homogeneity, specimens were taken from each of the four batches of material that were prepared and their flow viscosity measured in an instrument known as the parallel plate plastometer. The results are shown in Fig. 1. Despite the fact that this experiment was carried out in a 20th century laboratory of good reputation, by means of a modern instrument of high precision, we find ourselves in a position not too different from that of Lavoisier and Boyle in their combustion experiments. How can we distinguish between batches when so much fluctuation exists in test results from any one batch? Fortunately the experiment was designed with just such undesirable possibilities in mind. Figure 2 shows the same data, in the chronological order in which they were obtained. On each of four days, one specimen from each batch was tested, and the order of test of the four batches was varied from day-to-day. The design is a simple 4 x 4 Latin square. Two things are apparent: (1) the tremendous discrepancy between the level of values obtained on the first day and on subsequent days, and (2) the peculiar pattern low-high—high-low on the first, second, and third days, and to a smaller extent, on the fourth day. Thus, systematic errors do creep in, even in modern measurements, using advanced instrumentation. The simple device of performing the experiment in a certain way, according to a preestablished statistical plan, made it possible, not only to detect these errors but also to correct for their effect in the comparison of batches as shown in Fig. 3, in which the much smaller fluctuations are a measure of random experimental error.

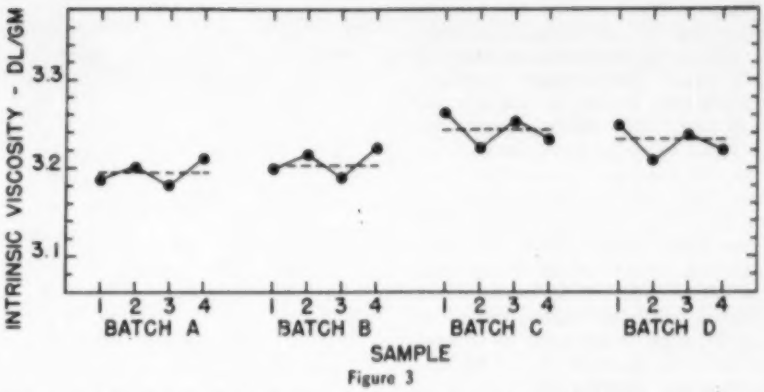

Figure 3

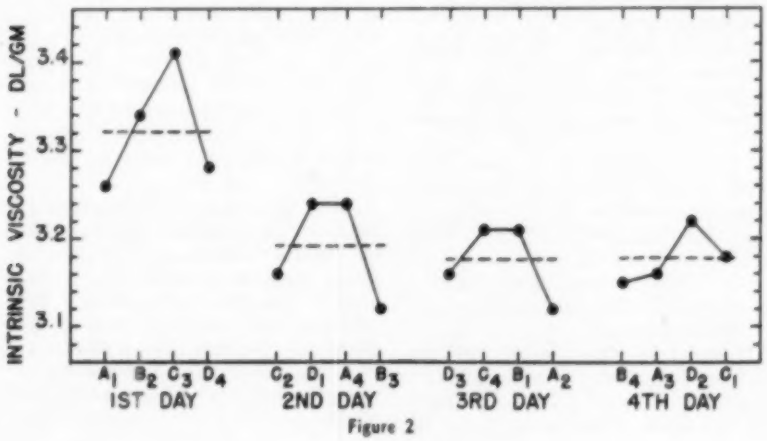

Figure 2

2. In discussing a specific aspect of testing in which statistics plays a major role, let us refer once more to the sentence quoted at the beginning of this article, in connection with Conant's remarks on Boyle's and Lavoisier's experiments. Conant talks about variation in results from day-to-day. In modern testing this phenomenon is still very much with us. In analytical chemistry, for example, the results of duplicate analyses run in parallel are known to show quite often an unusual degree of agreement, much better than that shown by samples run at different times; and this has led to a curious phenomenon: rather than praising the analyst for doing so well in his duplicates, the statistician has come into the habit of scolding him for this close agreement, pointing to the much larger day-to-day variability as the shining example of true precision. In a sense, this criticism is justified, since the agreement between duplicates gives too optimistic a picture of the precision of the data, leading to over-confidence in the reliability of one's results, but it is readily seen that this "excessive" agreement between duplicates could be, and actually has been turned into a real asset. If indeed one can obtain higher precision in parallel runs, the obvious thing to do is to run things in parallel. Here, one is usually limited by physical considerations which do not permit many items to be run simultaneously. The answer to this is the well-known "control sample."

An important contribution of statistical design is the transformation of the concept of the "control sample" into the much broader concepts of randomized blocks and especially incomplete blocks, in which proper experimental arrangements take the place of the control sample in relating the factors tested.

Suppose that we wish to evaluate the useful life of automobile tires, by measuring the rate of wear of their tread. The ordinary automobile has four wheels, so we can run only four tires simultaneously on the same vehicle. Suppose that we want to compare more than four tires. We could run a "control" on one of the four wheels, together with three experimental tires, and continue this operation by going from one set of three tires to the next. There are several reasons for which such an experiment must be vetoed. In the first place it would be uneconomical, wasting 25 percent of the testing potential in controls. In addition, one must face the fact that there is no such thing as a standard tire to be used as a control. Furthermore, the treadwear of a tire may vary several fold from one wheel to the next, on the same vehicle, so that the position in which the control occurs is an important consideration.

A statistical solution is shown in Table I. We wish to compare eight tires on a four-wheeled vehicle. Since only four tires can be tested at any one time, we divide the eight tires in two sets of four tires, and each set into two groups of two tires, as indicated, and we test one set at a time. In the first run, group AB is tested with group CD, and in the second run, the remaining two groups are tested. In order to connect the two sets, we now have to add two more runs: in run three we test AB of the first set with GH of the second set, and in run four, the remaining two groups. Remembering that our main difficulties are the effects of wheel-position and of run-to-run variations on treadwear, we proceed to compensate for these biases in our data.

TABLE I—Design for Tire Test

RUN	FRONT		REAR	
	Left	Right	Left	Right
1	A	B	C	D
2	E	F	G	H
3	G	H	B	A
4	C	D	F	E

First set	A,B	C,D
Second set	E,F	G,H

The first step in the analysis of Table I consists in rearrangement of the data in this table, by combining left and right, both in the front and in the rear, for each run. This leads to the scheme shown at the top of Table II, which upon rearrangement of runs two and three, gives the scheme at the bottom of the table. Note, that any two consecutive runs,

TABLE II

RUN	FRONT Left + Right	REAR Left + Right
1	A,B	C,D
2	E,F	G,H
3	G,H	A,B
4	C,D	E,F

RUN	FRONT	REAR
1	A,B	C,D
3	G,H	A,B
2	E,F	G,H
4	C,D	E,F

as well as the pair formed by the first and the last, have one group of tires in common. Such an arrangement, known as a chain block[2], permits a comparison of the effects of the four runs. Next, going back to the original design in Table I, combine runs one and two, as well as runs three and four. This yields the arrangement shown at the top of Table III, which upon rearrangement of front right and rear left, results once more in a chain block. Just as the chain block in Table II allowed for an estimation of run effects, the chain block in Table III allows for an estimation of wheel-position effects. Both these biases can now be eliminated from the individual 16 observations, permitting a comparison of the eight tire brands tested. If the precision of the test is insufficient to detect the minimum differences in which one is interested, the entire design of Table I can either be repeated a sufficient number of times, or preferably, be incorporated into a more elaborate design providing for the desired number of replications. The design of Table I, which is a chain block both according to rows and to columns, belongs to a general class of designs[3], which in view of the small number of replications required, should be widely applicable in engineering work.

Of special interest is the fact that a suitable arrangement of the object of test (the tires) in relation to the test conditions (runs and wheel-positions) permits one to circumvent the use of controls, and at the same time to increase the precision of the test.

TABLE III

RUNS	FRONT		REAR	
	Left	Right	Left	Right
1 + 2	A,E	B,F	C,G	D,H
3 + 4	C,G	D,H	B,F	A,E

RUNS	Front Left	Rear Left	Front Right	Rear Right
1 + 2	A,E	C,G	B,F	D,H
3 + 4	C,G	B,F	D,H	A,E

3. The notion of the statistical "block" pervades the entire field of physical, chemical, and technological testing. For example, in analytical work based on ultraviolet or infrared spectroscopy, measurements are usually made with reference to so-called "standards," because the instrument, a highly delicate optical and electronic piece of equipment, is too sensitive to be expected to maintain indefinitely the same equilibrium position. In some cases of infrared work, however, the process of emptying, cleaning, and refilling the cell with the various solutions is likely to cause fluctuations that are larger than the random changes of the instrument occurring in a relatively short period of time. Consequently, it is often advantageous to run a number of samples consecutively, limiting the number of runs of the "standard" to one for, say, every five or ten samples. Such a set is quite naturally a statistical "block," and designs based on blocks are indicated for this work.

The importance of blocks is also apparent in an altogether different field, that of interlaboratory experimentation. In most articles dealing with the principles of interlaboratory testing, it is urged that the test specimens be randomized before being allocated to the various participating laboratories. In many cases such a procedure is very unsatisfactory.

In a recent interlaboratory experiment, specimens cut from vulcanized rubber sheets were randomized and sent to several laboratories. Each laboratory conducted accelerated aging tests at several temperatures, keeping some of the specimens for test at yearly intervals of natural aging. The purpose of the test was to study the relationship between natural and accelerated aging. Thus, the primary objective was the most accurate possible determination of curves representing measured properties, such as tensile strength, modulus, and elongation in terms of time of aging.

Now, there exists published evidence[4] showing that the variability between sheets can be six to seven times as large as that within sheets. We will show that if this fact had been properly used in the design of the test, the precision of the data might have been increased several fold, without additional effort.

Suppose that from a single sheet of vulcanized rubber, six specimens can be cut. Assume furthermore that to each of seven laboratories we allocate three sets of six specimens, requesting the laboratory to make triplicate observations at six aging periods (for example, on the unaged specimens, and after 6, 18, 24, 48, and 72 hours.) This program requires a total of 126 specimens, i.e., 21 sheets. Let us now consider two alternative schemes for carrying out the experiment.

Scheme A

Twenty-one sheets are vulcanized. Each sheet is cut into six specimens. After thorough randomization of all 126 specimens, 18 specimens are sent to each of seven laboratories.

Scheme B

Twenty-one sheets are vulcanized. Three uncut sheets are sent to each of seven laboratories. Each laboratory is requested to conduct the aging experiment by allocating the six specimens of each sheet it receives to the six different aging times (unaged, and aged 6, 18, 24, 48, and 72 hours.)

Table IV represents the second scheme, but by omitting the column headed "sheet" it can also represent the first scheme. Since we are mainly interested in the effect of aging we will concentrate our attention on the column averages, or more precisely, on the differences between column averages, as reflecting the differences in the physical properties of rubber specimens aged for different periods. The superiority of Scheme B is now at once apparent: to detect the effect of aging we should arrange the experiment in such fashion that those differences between specimens that are not due to aging are as small as possible, and in Scheme B this is accomplished through the provision that for each specimen tested at one aging period there is a specimen *from the same sheet* tested at any other aging period. Sheet-to-sheet variation simply cancels out in the comparison of column averages. On the other hand, in Scheme A, the specimens tested at one aging period will not, in general, originate from the same sheet as those tested at another aging period. The standard deviation of a column average, in either scheme, is $\sigma/\sqrt{21}$, where σ represents the standard deviation of a single observation. The standard deviation of the difference of two column averages is therefore

$$\sqrt{\frac{\sigma^2}{21} + \frac{\sigma^2}{21}} = \sigma\sqrt{\frac{2}{21}}$$

Now, in Scheme A, σ comprises both within-sheet and between-sheet variability. Representing these respectively by σ_w and σ_s, we have* $\sigma = \sqrt{\sigma^2_w + \sigma^2_s}$ and, for the difference of column averages according to Scheme A:

$$\sqrt{\frac{2}{21}(\sigma^2_w + \sigma^2_s)}$$

In Scheme B, the proper formula is obtained by simply deleting σ^2_s.

*In a rigorous treatment, σ^2_s is weighed by a factor which, for large values of the number of sheets, approaches unity. In our case this factor = 0.96.

TABLE IV—Aging of Rubber

Laboratory	Sheet	Hours of Accelerated Aging					
		0	6	18	24	48	72
1	1	A_0	A_1	A_2	A_3	A_4	A_5
	2	B_0	B_1	B_2	B_3	B_4	B_5
	3	.	.	.	.	.	.
2	4	.	.	.	.	.	.
	5	.	.	.	.	.	.
	6	.	.	.	.	.	.
7	19	.	.	.	.	.	.
	20	.	.	.	.	.	.
	21	N_0	N_1	N_2	N_3	N_4	N_5
Average		E_0	E_1	E_2	E_3	E_4	E_5

Simple algebra will show that if $\sigma^2_s = 6\ \sigma^2_w$ (a plausible value in view of the findings reported in [4]) the standard deviation in Scheme B is only $1/\sqrt{7}$ times that applying to Scheme A. This means that a single observation in Scheme B is worth seven observations of the scheme of complete randomization.

Conclusion

In conclusion, it may be stated that the essential characteristics of the statistical approach lies in its emphasis on systematic planning for the purpose of neutralizing errors. The classical device of using "controls" leads to the broader concept of "blocks," and a skillful utilization of this concept can be extremely rewarding in terms of increased precision and reduced labor.

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QC Source Inspector

(continued from page 3)

10. Tooling and templates furnished the vendor for production purposes are also used as an inspection media without periodic reinspection to assure the accurency of the end item
11. Raw castings delivered to the vendor without physical and chemical certification.

Quite often the castings mentioned in No. 11 are ordered from the foundry with shipping instructions to deliver them direct to the sub-contractor. The failure to call out physical and chemical certification such as Florescent Penetrant, X-Ray, Heat Treat or Rockwell test may cause them to fail and be valueless for use in the end item. A rocket motor is a good example of this.

The QC source inspector encounters every one of these problems in the field and can only "put out fires" one at a time. He has to meet these problems with tact and diplomacy. The error is usually made at the prime plant he represents, but it may cost the vendor or the prime contractor money.

Better screening of a purchase order at the prime plant would solve these problems, provided that the man that does the screening can also screen a specification. Placing a man of this caliber in that position would not only save money but eliminate 75 percent of the QC source inspector's worries in the field.

Food for thought? He needs your support, so support him.

Local Section News

"... BUT NOT FORGOTTEN"

ALBANY On Sept. 15, 40 members were conducted on an extremely interesting tour of the Watervliet Arsenal. Charlie Armstrong led the subsequent problem session, which covered "Control charting of rare events." Wyatt Lewis spoke over the coffee cups and J. S. Wiberly, the principal speaker, presented an informative talk on the "Standardization of test methods."

BALTIMORE A meeting of the officers and the executive committee was held at the home of E. R. Harrall, section chairman, the evening of Sept. 22. After a delicious supper on Mr. Harrall's lawn, all went indoors for the business side of the meeting. The main topic of discussion was organization of the year's activities and committees.

BINGHAMTON The first meeting of the section was held at the Vestal American Legion on Sept. 20. The speaker was R. E. Wareham, QC consultant, whose topic was "Setting up a quality control program." At this meeting it was also voted to change the name of the section from the "Souther Tier section" to the "Binghamton section."

BIRMINGHAM The initial meeting of the new season was held Sept. 22. Robert R. Fuller, quality service director, Gulf States Paper Corp., Tuscaloosa, Ala., talked on methods of controlling quality in the paper industry. The state of Alabama is one of the largest timber producing states in the country and now appears to be on the road to becoming one of the largest paper producers.

BURLINGTON The first meeting of the 1955-56 season was held at Springfield, Vt., Sept. 21. After a plant tour of Jones and Lamson Machine Co. and an address by Holmes Whitmore, vice president and general manager of that organization, section members and guests adjourned to the Adnabrown Hotel for a cocktail hour. The banquet speaker was Dorian Shainin who spoke on "Reducing production difficulties by 1955 control techniques" with illustrated examples of the analysis of variance. Mr. Shainin, as always, entertained, instructed and pointed out the many avenues of investigation open to QC methods.

BUZZARDS BAY Irvin C. Kepner, manager of the quality engineering department at the International Business Machines Corp. in Endicott, N.Y., was main speaker at the September meeting which was held at the Continental Screw Co. Mr. Kepner described the quality control and quality engineering departments at IBM. Slides were used to show punch card and report methods of analyzing defective quality. The types of sampling plans used to control quality at the machine as well as various types of control charts were explained. The vendor rating plan and vendor certification program for evaluating incoming raw materials and purchases at IBM were outlined.

CENTRAL ILLINOIS The section was hosted by the Peoria Society for Quality Control at a kickoff meeting held at Hiram Walker & Sons in Peoria, Oct. 1. Approximately 65 persons, including members of both groups and their guests, were in attendance.

The early afternoon was spent in touring the facilities of the Barrett Div., Allied Chemical & Dye Co., and the Keystone Steel & Wire Co. After the tours the group enjoyed a cocktail hour, courtesy of Hiram Walker & Sons. During the evening technical sessions, Warren E. Jones of Management Controls, Des Plaines, Ill., gave a very interesting talk entitled "Whither quality control." He cited a number of pitfalls that quality control engineers had encountered during the past and indicated possible means of circumventing such difficulties in the future.

CHICAGO At the first afternoon-evening dinner meeting of the season on Sept. 14, the members and guest executives heard addresses given by men well learned in their respective fields. William Sadler of William Sadler Associates spoke on "Personnel relationships in quality control." Mr. Arthur Benscoter, director of quality control at the A. O. Smith Corp., Kankakee, Ill. addressed the group on "Quality control in metal fabrication and assembly of water heaters." Their topics were very enlightening and enjoyable.

The evening speaker, Dr. A. J. Feigenbaum of the General Electric Co. addressed the members and guests on "Industrial administration of quality control and management training," an address that will long be remembered.

There were a total of 77 members and guests present at this meeting.

CLEVELAND The annual clambake was held on Sept. 14. Fifty members and guests enjoyed the "best bake yet" and an evening of fellowship. The baseball game didn't uncover any Babe Ruths, but many sore muscles were scientifically evaluated and analyzed by the reliable bend test the next day.

CORNING -ELMIRA The recently founded Corning-Elmira section held its first meeting of the season in the Baron Steuben Hotel, Corning, N. Y. on Sept. 13. Simon Collier showed the interesting Johns-Manville film on quality control. About 80 persons were in attendance.

DANVILLE -SUNBURY The section held its first meeting of the season on Sept. 21. Forest G. Fales of Sylvania Electric Products discussed the theory and practical applications of probability.

All members attending were considerably impressed with the uses of this statistical tool.

DAYTON The kick-off for the 1955-56 season was a dinner meeting at Longo's Spaghetti House on Sept. 15. The speaker for this meeting was Richard Hausman of the Ford Motor Co., Cincinnati, Ohio who presented an interesting talk on "Fordomatic quality control."

Two training courses, a short introductory course in SQC with 21 registrants and an advanced techniques course in SQC with 12 registrants, are now being conducted by the educational committee of the section.

ERIE The officer's monthly luncheon was held on Sept. 8 at Shugarts. Plans for management night were discussed. The new meeting notices, recently received from the printer, were shown resulting in a general comment of, "very sharp indeed."

GEORGIA The Atlanta group of the section met on Tuesday night, Sept. 27. Donald S. Holmes of the experiment station, Georgia Institute of Technology, Atlanta, talked on "What is quality control?" He developed the purpose of a management team representing sales, design, facilities, purchasing, production, inspection, and distribution. Quality control must consider the cost of quality and also contribute to reduction in cost of product.

HARRISBURG The section has been conducting both a basic and an advanced course in statistical quality control techniques. They are held every Monday evening from 7-9 pm at the Manufacturers' Association of York located in York.

INDIANAPOLIS The kickoff meeting of the section preceded by a visitation of the Western Electric Co. was received with excellent response. L. B. Bornhauser, general manager of Chrysler Division, delivered an exciting message.

INDIANAPOLIS Columbus Subsection The subsection had a very successful kickoff meeting on Sept. 8 with more than 30 members and guests in attendance. Charles R. Hicks' talk on "Getting the most out of experiments" made the occasion one to remember.

KANSAS CITY The first meeting of the season was held on Sept. 14 at the Blue Hills Restaurant. After dinner and a short business meeting, the evening was spent in indoctrinating a number of visitors and new members. The program for the year at hand was presented and approved.

LINCOLN The section met at the Hotel Capitol, Friday evening, Sept. 16. The program was designed for prospective members. Presentations of seven minutes duration were given by members of the section explaining how SQC techniques have been used to the benefit of the concerns represented. Qualified prospective members were invited to join the organization.

LOS ANGELES Charles Bicking, office of chief of ordnance, addressed the first meeting of the new season. His discussion of the use of SQC in designing and evaluating experiments was both interesting and informative. The section was given an insight into the advantages available with this use of SQC.

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LOUISVILLE Two courses, sponsored by the section, are being presented by the University of Louisville in their department of adult education. "Quality control" is a two credit hour course, while "Statistical analysis for chemistry" will grant three credit hours. Classes started Sept. 27.

MICHIGAN The tenth annual Michigan forum was held on Sept. 17 at the University of Michigan, Ann Arbor. Registrations for the event included over 500 members and guests. Feature attraction of the day was the luncheon address by C. E. Heitman, assistant general manager of A. O. Smith Corp., Milwaukee. The event was regarded as highly successful and the fine attendance is proof of industry's interest in quality control. Part of the success of this function should be attributed to Harmon Bayer's efforts publicitywise. Extensive newspaper coverage and the appearance of Tom Anderson on WWJ radio added considerable interest and prestige to the affair.

A meeting of the officers and committee chairman was held at Detroit's Park Shelton Hotel on Wednesday, Sept. 28 at 7 pm. Final plans were made for the activities which are scheduled during the 1955-56 season.

MILWAUKEE Dr. J. M. Juran was the principal speaker at the section's annual management night meeting, Sept. 12. Some 110 persons attended the dinner meeting and Dr. Juran's talk, "Managing a quality control program." The only casualty was the hotel's circuit breaker; but even this could not scuttle the effectiveness of Juran's talk. We in Milwaukee felt this was one of the best "grass roots-brass tacks" speech ever presented.

Operation "Yearbook" continues at a steady pace according to Irv Schoeninger, committee chairman. Unless unforseen difficulties occur he believes there is a 0.95 probability of getting the book from the printer for mailing by Thanksgiving. The Milwaukee section committee members have discovered that a friendly wager on the probability of a surname beginning with I, Q, or X enlivens what would otherwise be just another alphabetizing job.

MONTREAL A most excellent forum and social evening was held Sept. 21. The turnout was double that for the previous year—39 members and guests— and excellent refreshments were fully enjoyed. The enthusiastic discussions of acceptance sampling and statistical process control helped our new executive off to an excellent start.

MUNCIE Dr. A. C. Rosander spoke on the topic "Demonstration of SQC methods for workers and management" at the Sept. 15 meeting. This being our first meeting of the 1955-56 season, we were pleased to have 32 members and friends present.

NEW HAVEN On Sept. 13, Dr. A. V. Feigenbaum, manager of quality control and cost reduction for the General Electric Co. at Schenectady, N. Y., spoke to the section on the topic "Management of the quality function." The dinner meeting was held at the Colonial House, Hamden, Conn. and the entire program was enjoyed by the good attendance.

PHILADELPHIA Management night, Sept. 16, an annual affair of the section, opened the 1955-56 season of activities. Wade R. Weaver, Republic Steel Corp., spoke on "Management acceptance of quality control."

PITTSFIELD The first meeting of the section's current program was held on Sept. 8 at the Stanley Club, Pittsfield. There was a good turnout for dinner and for the interesting talk which followed, given by James L. Dolby of General Electric Co., Schenectady. Mr. Dolby discussed the application of statistical methods to budgetary control.

The first session of a new course in intermediate industrial statistics, offered by the Extension Service of the University of Massachusetts, was held in Pittsfield High School on the evening of Sept. 22. Many members of the section were among the 50 men enrolling for the class which will meet every Thursday evening for 12 weeks. The instructor is John Hinchen of Monsanto Chemical in Springfield, who has conducted several similar courses in the past with considerable success

RHODE ISLAND On Sept. 21 Dr. Joseph M. Juran spoke to 195 interested and well pleased quality control gospel seekers. His subject was "The top executive's resposibility for quality." Complimentary tickets mailed to the complete mailing list contributed toward the largest turnout the section has ever experienced.

ROCHESTER John Allderidge, staff consultant to the assistant director of industrial engineering at the Kodak Park Works of the Eastman Kodak Co., presented "Sampling for something besides quality" at the Sept. 20 meeting of the section.

ST LOUIS We were honored at our first meeting on Sept. 16 by having as a special guest, Mason Wescott, chairman of the editorial board of IQC. After the formal presentation by Leon Bass, vice president of ASQC, a free-for-all discussion on the journal and advertising in it ensued.

The ten day intensive quality control educational course at Washington University in cooperation with their department of industrial engineering Sept. 8-16 was furthered through the excellent help of five members of the section. The following gave inspiring accounts of their experiences in specific application of QC techniques: Floyd Browning, Wagner Electric Corp.; Thomas Leahy, White-Rodgers; Jack Rutledge, McDonnell Air Craft Corp., and Arnold Braun, Carter Carburetor. Joseph Movshin, Ramsey Corp., acted as instructor for the last two days of the course.

The annual one day fall conference "Managing for quality control" held on Sept. 24 met with a fine attendance of both local and out of town quality minded people.

SALT LAKE CITY The section began its 1955-56 season with a dinner meeting Sept. 22 in the Union Building on the University of Utah campus. The speaker was Robert I. Tenney, president of Walt-Henius Institute, Chicago, Ill. His subject, "Marketable uniformity in batch operation," coordinated statistical techniques from several fields for both process and metal working operations.

SAN DIEGO On Sept. 19 the section held its first regular meeting under the leadership of the new chairman, B. R. Swarts. J. Walter Howard presented an informative lecture on the "Application of light to quality control."

SCRANTON-WILKES-BARRE Our initial fall meeting was held Sept. 21 at the YMCA Bldg., Scranton, Pa. A large number of members and several guests were present. Ralph E.

Wareham, past president of the Society and director of the Army ordnance quality control courses for the past five years, gave an interesting and illustrated discussion, with the use of charts, showing how he introduced QC programs in various leading industrial companies.

SEATTLE The first regular monthly meeting of the 1955-56 season was held on Sept. 13. The section was addressed by Prof. Berl W. Owens of the mechanical engineering department of the University of Washington. The title of his talk was "Time utilization study" with the accent on the work sampling facet of the subject.

SOUTH TEXAS A course, "Advanced engineering statistics," sponsored jointly by the University of Houston and the section, is being instructed by C. T. Shewell, Humble Oil & Refining Co. The course is three hours per week for seventeen weeks and carries graduate credit at the University.

SOUTHERN CONNECTICUT The executive committee held its meeting on Sept. 14 at the Manufacturers' Association Office, Bridgeport. The program for the 1955-56 season has been formulated and is one of the best in quality control programming. The committee feels that this is a well diversified program and will have nationally-known speakers and top-flight experts in their respective fields on the speakers rostrum for our meetings. Frank Walsh, arrangement chairman, reported he has arranged with the Stratfield Hotel to hold the section meetings at this fine hostelry, as in the past. Ed Dawes, treasurer, gave his report and revealed our section is in a healthy financial state. The report is to be mailed to the membership.

STATE UNIVERSITY OF IOWA The first meeting of the season, Sept. 29, in addition to providing first hand information regarding present day QC applications in a government arsenal, provided an excellent opportunity to review the entire history of the Rock Island Arsenal, as displayed in the arsenal museum. The dinner speaker, D. L. Meyers, chief of the engineering division at the arsenal, provided the group with a thought stimulating talk on "The possibilities of space flight." On Friday morning, the section heard R. W. Boeke talk on "Probability of the OC curve." Immediately after the problems clinic a drawing was held for door prizes with the following winners: R. A. Messier, H. R. Turney, and C. C. Heldt.

TORONTO The members who were present at our Sept. 14 meeting were given a most enlightened address on the three basic phases of statistical principles of quality control by Prof. S. B. Zobel. On Sept. 21, 30 members turned out for our plant visit through the P. L. Robertson Mfg. Co., Milton. After a very interesting tour, our host directed the group to the Milton Inn, where we sat down to a delightful supper of southern fried chicken. Fred Meity, chief engineer, spoke a few words of welcome on behalf of the P. L. Robertson Co. Our chairman, Bob Gardno, thanked Fred on behalf of the section.

The Niagara Peninsula group of the section started off with a bang at their meeting on Sept. 12 which took the form of a training course in statistical quality control. Seventy three persons attended.

TRENTON On Sept. 9, Ralph E. Burt, president of a national advertising agency in Springfield, Mass. and founder of National "U" Assoc., spoke before the section on "Human relations in quality control." After the lecture, beer and pretzels were served to aid good fellowship.

WESTERN MASSACHUSETTS The first meeting of this section was held on Sept. 20 at the Sheraton-Kimball Hotel, Springfield. Maurice Blew, QC engineer of Strathmore Paper Co., spoke to 29 members and eight guests relative to "Measuring quality for your customers." His talk devoted considerable time to not only auditing the product shipped to the customer but also emphasized the need for auditing shipping instructions, labeling errors, and pricing errors. Some time was spent on discussing the use to be made of a monthly analysis of customer complaints.

WINDSOR The section held its first meeting of the season on Sept. 26 with 24 members and 32 guests in attendance. The guest speaker was A. S. Harrison, purchasing director of the Ford Motor Co. of Canada, Ltd., who spoke on "How purchasing uses quality control." His interesting talk was supplemented by a film entitled "6000 Partners."

WINNEBAGO An organization meeting of the elected officers of the section was held at Green Bay on Sept. 19 to round out the program for the coming year. Officers present were E. G. Powell,

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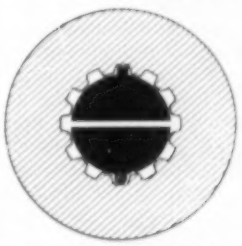

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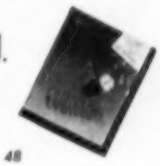

GET THE FULL FACTS — REQUEST BULLETIN 48

L. J. Manders, Paul Ebert, John Nelson, and Bob Lace. A program was developed which would be of interest to all members.

A training session prior to the meetings has been arranged for all personnel who have been subjected to SQC and need further information to aid them in understanding the principles and aspects of QC.

WORCESTEP James L. Dolby, General Electric Co., Schenectady, N. Y., delivered an excellent talk on "Prediction of budgeting rejections" at a meeting of the section on Sept. 15. His talk was enjoyed by all present.

"... CAST THEIR SHADOWS BEFORE"

ALBANY The December meeting of the section will be conducted as a joint meeting with the Hudson section for the advancement of management. It will be held at the Hendrick Hudson Hotel in Troy, N. Y. The featured speaker will be Leonard Seder who will propose the question "Who is responsible for quality?"

BALTIMORE The Dec. 14 meeting promises to be an interesting one. Prof. A. J. Duncan of the Johns Hopkins University faculty will discuss the fine points and some new concepts of $\overline{X}$ and R charts at Johns Hopkins University.

BINGHAMTON The meeting for Dec. 6 will be held at the Vestal American Legion. A. B. Mundel, Sonotone Corp., will speak on "Quality control in the electronics industry."

BURLINGTON At the Dec. 7 dinner meeting, Dr. George R. Stibitz will speak on "Evaluation methods." Dr. Stibitz, who lists among his inventions "Stibitz" computers at Aberdeen Proving Ground and at National Advisory Committee on Aeronautics, Langley Field, Va., has also worked for the Bell Telephone Lab and the National Defense Research Committee. The section is indeed fortunate in having a consultant of Dr. Stibitz's caliber residing in Vermont.

CHICAGO On Dec. 7 the first of a group of plant tours, arranged by E. G. Freund, chairman of the plant tour committee, will be made through the International Harvester Plant, Melrose Park, Ill. Format of the tours include a talk on the application of QC techniques in the subject plant given by a member of that plant. The intent of such tours is to give the membreship first hand knowledge of the application of QC techniques in various industries.

On Dec. 14 at the "do it yourself" meeting arranged by Messrs. Henry Becker, Ralph Haertel, and Richard Ede, members of this section will discuss and analyze an actual problem encountered in our field. The actual solution will be given before the close of the meeting. This and future sessions should prove very interesting.

CLEVELAND The Dec. 2 meeting will be held in Akron, Ohio as a joint meeting with the Youngstown section. It will consist of a plant tour of the Goodyear Rubber Co., Akron, and a panel discussion on "Relative efficiency of various sampling plans." A dinner and meeting will be held at the Goodyear Rubber Co. A good attendance is anticipated.

DAYTON The regularly scheduled meeting for December will be held at the National Cash Register Co. on Dec. 8 with George S. Hargreaves, National Cash Register Co., as the principal speaker. Mr. Hargreaves' subject will be "From kinks to scratches."

ERIE On Dec. 14 Neil Brown of Manning, Maxwell and Moore, Cleveland, Ohio will present a talk and demonstration of "Electronic process control."

HARRISBURG The next meeting of the section is scheduled for Dec. 7 and will be held at The Willows in Lancaster. The speaker for the evening will be Simon Collier, director of quality control, Johns-Manville Corp., New York City.

INDIANAPOLIS
Columbus Subsection Our next meeting to be held Dec. 8 will feature Charles Meyer, Arvin Industries, and his very interesting subject, "Motovation for better quality."

KANSAS CITY Wives have been invited to attend with members and guests for the Dec. 10 meeting. A social evening of dancing and refreshments has been planend at the Homestead Country Club.

LOUISVILLE On Dec. 14, members of the section will be guests of the General Electric Co. Tours of the range and refrigerator departments at Appliance Park have been planned.

MICHIGAN On Dec. 9 at the Science Hall of Wayne University in Detroit, Dr. Paul K. Leatherman, Falstaff Brewing Corp., will talk on the subject, "Some applications of quality control for the brewing industry."

MILWAUKEE On Dec. 12 the section will observe "past presidents' night" at the annual christmas party. Once a year, the past presidents are put to work on their (?) night; hence the philosophical oratory from the honored ex-officio group will review the progress of SQC and ASQC in the Milwaukee area. In true Milwaukee tradition and christmas spirit, golden amber fluid will be consumed gratuitously.

MUNCIE K. E. Ross, chief inspector of R.B.M. Division Essex Wire Corp., Logansport, Ind. will speak before the members and friends of the section on Dec. 15. His topic will be, "Degree of control sampling continuous flow charts."

NEW HAVEN On Dec. 6, the section will hold a "clinic meeting" similar to those held in the past which have proven to be most popular. Members will divide up in groups to discuss various phases of quality control.

PARKERSBURG Ervin F. Taylor, North American Aviation Corp., Columbus, Ohio will present "Discovery sampling" at the Dec. 6 meeting to be held at the Lawnsdale Hotel.

PHILADELPHIA The annual christmas party will again be held at the Germantown Cricket Club on Dec. 10. Ladies and their member husbands will eat, dance, and be entertained while donated prizes are disbursed.

PITTSFIELD The fourth dinner meeting of the section's current program will be held on Dec. 1 at the Stanley Club. Two local members will share the speaking assignment: Dr. Laurence Spooner of General Electric Co., Pittsfield, will discuss the uses of probability paper; George Lyman, Peter J. Schweitzer, Inc., Lee, will talk on loss control in the paper industry.

RHODE ISLAND Roy G. Volkman of the U. S. Rubber Co. will speak on "The acceptance control chart" at our Dec. 15 meeting to be held at 8 pm in the Providence Engineering Society Building.

ST. LOUIS A joint meeting with the Purchasing Agents Assoc. of St. Louis will be held Tuesday, Nov. 22, at the Sheraton Hotel. K. R. Geist, director of purchases, and A. D. Foote, works purchasing agent, both of the Allis-Chalmers Mfg. Co., Milwaukee, Wis., will speak on "Quality control of purchased materials."

The Milwaukee Purchasing Agents group sponsored the publishing of a book, *Industrial Purchasing*. Mr. Geist and Mr. Foote are the authors of a chapter called "Quality control of purchased materials."

This meeting promises to be educational as well as enjoyable to both associations.

SALT LAKE CITY On Dec. 8 the speaker will be George A. Cohan who is a member of both the Chicago and Salt Lake City sections. Mr. Cohan, deputy chief for quality at Hill Air Force Base, Utah, will speak on the subject "Vendor certification."

SOUTH TEXAS Our annual party is scheduled for Dec. 14. This will be a stag party with the program to be announced at a later date.

TORONTO At our regular meeting to be held Dec. 7, we will have as our guest speaker R. Vance Ward, Canadian Industries 1954 Ltd., Montreal. Mr. Ward will speak on the subject, "SQC in the chemical industry."

The Niagara Peninsula group will hold their regular meeting Nov. 21 in The Thompson Products Ltd. cafeteria, South St., St. Catharines, Ont., at 8 pm. A Dec. 6 dinner meeting at the Queensway Hotel is also planned.

TRENTON On Dec. 2, Dr. Mason E. Wescott, lecturer, consultant, author, and Professor at Rutgers University, will address the section on the topic, "What's the difference?"

WINNEBAGO The program chairman has announced that A. R. Jackson, Mitchell Manufacturing Co., has been engaged as the speaker for the Dec. 5 meeting to be held at Manitowoc. His topic will be "Vendor certification program."

Have YOU paid your 1955-56 dues to your section treasurer?

WORCESTER Ervin E. Schiesel, chief engineer of the Mattatuck Mfg. Co., Waterbury, Conn., will be the speaker at the Dec. 8 meeting of the section. His subject will be "Engineering standards and tolerances."

YOUNGSTOWN The Youngstown section and the Cleveland section will join forces and visit the Goodyear Rubber plant in Akron on Dec. 2. A large group is expected to take in this trip.

"AS YE SOW . . ."

CORNING -ELMIRA An educational program will be started late in November. The first group will cover the fundamentals of quality control in four sessions. It will be conducted by R. Bechhofer of Cornell University and held at the Westinghouse Plant in Horseheads, N. Y.

INDIANAPOLIS The following training courses are scheduled for Stuart Hall of the Arsenal Technical High School: Basic course—the new industrial quality control; Sampling course—acceptance sampling in industry; Intermediate course—statistical analysis; Advance course—administration of quality control technique in industry.

LOS ANGELES Kenneth R. Willhite, North American Aviation Inc., chairman of the 1956 Western Regional ASQC conference, announced

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that the conference will be held at the Statler Hotel, Los Angeles, on Monday and Tuesday, August 20-21, 1956.

MICHIGAN As a part of the advanced educational program, Dr. C. C. Craig, University of Michigan, will conduct a class on "Analysis of contingency tables" on Dec. 9 before the regular section meeting. This is the second in a series of advanced techniques in statistics being presented for the benefit of section members. These courses are held from 5:15-6:30 pm, allowing participants a break before the regular programs.

NORTHEASTERN INDIANA The section is to take part in "Engineers' Week" to be conducted Feb. 19-25, 1956. All engineering organizations in the Fort Wayne Area, numbering approximately 1200 engineers and comprising eight of Fort Wayne's leading engineering societies, will be represented in the supporting activities. The purpose is to acquaint the general public with activities of the engineering profession and their direct relations to progress. Plans are being furthered to secure a nationally known speaker for a banquet to be held at the close of the week's activities. The general activities are expected to include radio, newspaper and TV coverage. Full particulars and the program will be highlighted in a future issue.

SAN DIEGO The section, with the San Diego Junior College and the San Diego Vocational School, is co-sponsoring an elementary course in statistical quality control. Credit is granted by both educational institutions either toward a junior college associate of arts degree or toward a certificate from the San Diego Vocational School. The instructor this year is R. M. Hubsch, section chairman for the year 1954-55.

SOUTHERN CONNECTICUT The executive committee is planning to offer basic courses in QC. The course will cover frequency distributions, control charts, and sampling plans. It will be designed to lay the ground work for a working knowledge of QC and will be suitable for inspectors, industrial engineers, supervisors and men of management who desire to look into QC and its concept. A. Henry Morgan, education chairman, has announced that these courses will be given in Waterbury, Conn., and Stamford, Conn. He is planning on having the courses start in December but members will be advised on the definite time at the next meeting or by mail.

CORRECTION NOTICE

Due to a typographical error, the secretary and treasurer as reported for six sections on page 29 of the October issue are incorrect. The sections affected and their correct officers are as follows: Utica—Joseph P. Drozd, General Electric Co. and Alexander C. Cirillo, Chicago Pneumatic Co.; Washington—Catherine Hock and Andrew H. Nash. US Naval Gun Factory; W. Massachusetts—Carol O. Baumann, Monsanto Chemical Co. and George G. Rice; Wichita——Warren G. Lyman and Max D. Eaton; Windsor—C. E. Laforet and James McMillan; and Winnebago—Edward Schuch, Fairmont Foods Co. and Paul A. Ebert, Kohler Co. The officers are listed as secretary and treasurer respectively. Our apologies to the sections and officers.

RELIABILITY AND QUALITY CONTROL IN ELECTRONICS The Second National Symposium on reliability and quality control in electronics will be held in Washington, D. C., on Monday and Tuesday, Jan. 9-10, 1956. This symposium is being sponsored by the Professional Group on Quality Control of the Institute of Radio Engineers, the Electronics Division of the American Society for Quality Control, and the Staff Committee of the Radio-Electronics-Television Manufacturers Association.

This two-day national symposium will have nine sessions, featuring experts in the field of quality control from all branches of the industry, research, and government agencies.

The following is a brief resume of some of the main topics to be covered:

(1) Case histories of quality control applications in radio and television.
(2) The relationship of military electronic equipment to quality control.
(3) Clinic of current quality control application problems in the electronic industry.
(4) Tutorial theory and philosophy of quality control.

For information on registration, hotel rooms, trips, etc., write to Victor Wouk, Publicity Chairman, Beta Electric Corp., 333 E. 103rd St., New York 29, N. Y.; or Max Tall, Registration Chairman, Vitro Corp. of America, 962 Wayne Ave., Silver Springs, Md.

1957 CONVENTION HOST GROUP ANNOUNCED Wade R. Weaver, chairman of the general convention committee, has announced the formation of the host group for the 1957 convention which will be held in Detroit. Those who are serving on this host committee are well known for their extensive interest in ASQC activities in and around Detroit. They are:

Herman H. Bogin—manager, industrial statistics, Parke, Davis & Co.
Harmon S. Bayer——quality control consultant
W. H. Smith—manager, quality control, Gen. Mfg. Div., Ford Motor Co.
Harry L. Wehrly—manager, quality control, The Dow Chemical Co.
Clarence R. Burdick—manager, quality control, Houdaille-Hershey Co.
J. Clayton Knapp—supt., quality control, Ford Motor Co. of Canada
Donald M. Spath—chief inspector, General Products Corp.
Stephen J. Adams, quality control engineer, Wolverine Tube, Div. of Calumet & Hecla, Inc.

The group will work in close liaison with the general convention committee in the design and execution of the convention.

"FOR MANY ARE CALLED, BUT FEW ARE . . ."

BINGHAMTON The officers elected for the 1955-56 season are as follows: T. H. Johnston, IBM Corp., Endicott, N. Y., chairman; T. N. Lemoncelli, E. J. Shoe Corp, Endicott, N. Y., vice chair-

man; G S. Lucas, General Electric Co., Johnson City, N. Y., secretary; R. E. Kiely, General Aniline & Film Corp., Binghamton, N. Y., treasurer.

GREATER MUSKEGON Correction please! Our chairman and vice chairman were reported incorrectly in the October issue. Charles C. Duff, Anaconda Wire & Cable Co. is our chairman, and Glenn A. Bailey, American Coil Spring Co. is our vice chairman.

SCRANTON-WILKES-BARRE The new officers for the fiscal year 1955-56 are: chairman, Joseph Gallagher, W. L. Maxson Corp., Old Forge, Pa.; vice chairman, Carl Larson, US Hoffman Machinery Co., Scranton, Pa.; secretary, Thalia B. Snyder, General Textile Co., Carbondale, Pa.; treasurer, Edward J. Baker, W. L. Maxson Corp., Old Forge, Pa.

WINDSOR The following is the list of officers for 1955-56: chairman, M. F. Kennedy, Bendix-Eclipse; vice chairman, Geo. Dowling, Ford Motor; treasurer, James McMillan, Ford Motor; secretary, C. E. Laforet, Bendix-Eclipse.

WINNEBAGO The newly elected officers for the coming year are: E. G. Powell, Marathon Corp., chairman; L. J. Manders, Charmin Paper Mills, vice chairman; E. Schuch, Fairmont Food, secretary; Paul Ebert, Kohler Co., treasurer.

DIVISIONS

Administrative Applications Division

Organization of the Administrative Applications Division is now complete, subject on a few points to approval by the Division Council at its meeting in Milwaukee on Nov. 16.

In addition to the officers and committee chairmen announced in the August issue of *Industrial Quality Control* the following chairmen have been appointed: Clerical and Accounting Sub-division, Blair E. Olmstead; Industrial Engineering Sub-division, Dr. Harry G. Romig; Management Sub-Division, Maj. Gen. Leslie E. Simon; Committee on Committees, L. S. Eichelberger. J. Y. McClure will serve as Division trustee.

District Councillors are: (1) Ervin E. Schiesel; (2) S. P. Zobel; (3) Dr. Alex Hart; (4) Robert A Lucas; (5) Morris Hamburg; (6) Charles A. Bicking; (7) S. H. Troxel, Jr.; (9) K. C. Brown; (10) Edward Richards; (11) Charles L. Matz; (12) L. S. Eichelberger; (13) Dale L. Lobsinger; (14) James L. Coburn; (16) E. D. Goddess. Districts (8) and (15) have less than ten members each.

The Publications Committee has already distributed a bibliography of about 100 articles on statistical quality control work in administrative areas, and is working to extend this list. They have also compiled a list of more than 25 speakers and subjects in this field.

The Division is represented by four speakers on the program of the 10th Midwest Quality Control Conference in Milwaukee Nov. 17-18. They are Dr. Carl Noble, who will lead a panel discussion on "Facilitating Communications between the Papermaker and Printer via SQC;" Harmon S. Bayer, whose paper is "Selling SQC to Management;" Dale L. Lobsinger, who speaks on "SQC Looks at Supervision;" and W. E. Hoehing, who presents "Statistical Inventory Control."

Chemical Division

The division council held its first meeting of the year in Ann Arbor, Mich., Sept. 16-17. The council members in attendance accomplished a great deal in the areas of growth and expansion of services to division members. A tentative write-up covering the prescribed duties and suggested activities for councilors was prepared to assist these individuals in corelating division activities at the section level. The education committee is formulating plans for a Boxonian Technique Training Conference early next year and are exploring the field for possible future training conferences in SQC methods in the petroleum and food industries. The foods committee is well along in their work of preparing a bibliography for the food industry and the formulation of standard taste best procedures. The paper and graphic arts committee participated in the Nov. 4 clinic of the Chattanooga section and the 10th Midwest conference. They will also furnish speakers for the 1956 national convention at Montreal. The program committee has completed their work of providing seven sessions for the Montreal convention.

R. M. Hofstead has found it necessary to resign as our program committee chairman. We regret the loss of Bob from this position as he has done an outstanding job both from the standpoint of quality and promptness. Chairman Wehrly will appoint a successor in the near future. Another resignation was received from M. N.

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Goff, who had just started his work as chairman of the newly established rubber committee.

Textile Division

The tentative program for the Sixth annual convention of the Textile Division to be held at the Institute of Textile Technology, Charlottesville, Va., Feb. 13-15, 1956 has been completed.

The program for Monday, Feb. 13 consists of registration, opening remarks by Dr. Jack Compton, technical director, ITT, and welcome by Dr. L. H. Hance, president, ITT; Management Aspects of Quality Control—S. Rudo, chairman; Evenness Testing of Sliver, Roving and Yarn—Wm. Harris, chairman; social hour, Monticello Hotel; banquet, Monticello Hotel (includes showing of film prepared by educational film task group.)

Tuesday, Feb. 14: How Much Twist in Roving and Yarn—Dean C. L. Adams, chairman; Task Group Meetings—cotton raw stock, staple fiber picker laps, staple fiber sliver and roving, staple yarn, fabric imperfections; Processing Quality Control—W. S. Smith, chairman; Manufacturers' Quality Control Committee.

Visits to Thomas Jefferson's home in Monticello, the University of Virginia, and the Research Laboratories at ITT, are planned for Wednesday morning, Feb. 15.

Educational sessions, with O. P. Beckwith as chairman, are scheduled from 2-5 pm on Monday, Feb 13 and again from 9-10:30 am Tuesday, Feb. 14.

MEMBERSHIP CORNER

Julian Harrison Toulouse, vice president of ASQC, has prepared the accompanying graph concerning our membership history since 1946.

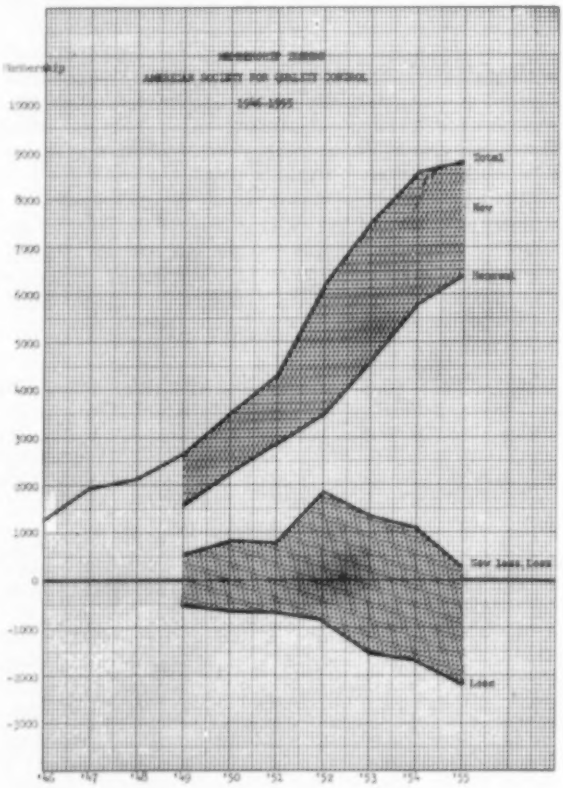
He also includes some very significant thoughts in a letter to Arthur Bender, Jr., president of ASQC. May we quote:

"I've charted the figures sent to me in order to show several things. One is the trend of membership which seems to have gone up steadily, another is the trend in renewals which went up fairly well until about 4 years ago. The other is a line for those not renewing which started suddenly downward about 4 years ago. The net gain, the difference between new members and lost members, is shown as the intermediate chart and I think the most serious thing is shown by its sudden trend downward about 1952. Up to that time we had been having a steadily increasing net gain but since then we have had a rapid loss in the net gain of new members minus lost members, getting down to a total of only 232 last year.

I think two things are very important. The first is the campaign for renewals of old members. It is the loss of old members which is most important to us as shown by the chart. We must find a way of keeping the members that we have. The field for new members will someday reach a point where there could be a logical ceiling. At that time the society will either reach a plateau in membership, or if the trend toward losing membership continues, the membership in the society will decline.

The second point is of course the securing of new members but personally I am beginning to think this is secondary in importance to the retention of old members."

Dr. Toulouse's observation about renewals being probably more important than getting new members in the long run has been echoed by many people. The membership committee, ASQC, has been hammering away at this problem for many years. We have sent out manuals and newsletters specifically designed to help sections lick it. We have provided schedules for campaigns and programs and suggested letters to send to non-renewed members. We have urged telephone campaigns, etc. Does your section know about these aids, and are they actively using them? If not, please write for them. But apparently we have not been able to turn back the tide of increasing loss in this area. Can you help? Every member in ASQC can have a stake in this. Your comments are not only welcome but actively solicited. Please write: Harmon S. Bayer, Chairman, National Membership Committee, ASQC, 1154 Book Building, Detroit 26, Michigan.



SIGNIFICANT DIFFERENCES

Technical vocational guidance clinics have been instituted at the Roberson Memorial in Binghamton and are being sponsored by the Joint Technical and Engineering Council of the Southern Tier. The Binghamton section of ASQC has taken an interest in these guidance meetings and expects to put one on extolling the merits of QC engineering as the field for the student.

Congratulations to Gardner Hailes, Birmingham section, who has accepted a new position as QC director of Rowe Mfg. Co., Whippany, N. J. Now, we shall look forward to the machines not taking our money without giving us cigarettes.

Henry Jacobson, national director for the Chicago section, has changed positions and is presently affiliated with the Schiable Co. of Cincinnati, Ohio. He will continue as national director for the section for the 1955-56 term.

Clement N. Granoff, Corning-Elmira section, has been appointed manager of quality control and customer service of the Elmira plant of the Thatcher Glass Mfg. Co. He succeeds A. E. Manro who was named manager of the Lawrenceburg, Ind., plant of the same company.

The Southern Regional Committee on Statistics took action on five points during a meeting held Oct. 8 in Atlanta. Among the statistical departments represented at the meeting were the universities of Georgia, Tennessee, Kentucky, Alabama, Florida, North Carolina, Texas and Virginia; Virginia Polytechnic Institute, Oklahoma A and M College and North Carolina State College.

A membership drive was inadvertently attributed to the Kansas City section in the September "Significant Differences" column. It made reference to the fact that the section hoped to increase its membership 100 percent, having a present membership of 25. This should have been credited to the Greater Muskegon section and their membership chairman, Roland W. Beyer, Keller Tool Co. Our apologies for any inconveniencies that this may have caused to either section.

The Kansas City section has endorsed a course in "Statistical quality control" offered at the evening division of Rockhurst College. The course is being taught by Glennon M. Putthoff, senior quality control analyst, Bendix Aviation Corp., who is a member of the section.

Dr. Harry G. Romig, Los Angeles section, has joined the engineering staff of Summers Gyroscope Co., Santa Monica, Calif., and has been elected president of Quality Control Engineers, Inc., Los Angeles.

The Louisville section will be cooperating with several other societies Dec. 5 when a tool show is to be presented.

Jack Kidwell, Michigan section, has recently accepted a position in quality control with Glen L. Martin of Baltimore, Md. Jack's many friends in the section wish him well in this new affiliation.

T. A. Halmi, Michigan section, has been named to replace Joe Randall—as reported last month, Randall accepted a position with Anheuser Busch of St. Louis—in the quality control department of the Chevrolet Division of General Motors Corp.

Some 60 to 80 persons attended the quality control panel discussion at the SAE National Tractor Meeting Production Forum on Sept. 12 at the Hotel Schroeder in Milwaukee. The all ASQC panel lead by Ed Oakley, Delco-Remy Div., GMC, subbing for our flu caught ASQC president Art Bender, did themselves proud. If participation in a four hour lively discussion is any criteria of success, this was it. Panel secretary John S. Randall, Anheuser-Busch, certainly has a big job in writing up the multitude of comments for the SAE JOURNAL. The ASQC panel members were: Dale A. Cue, A. O. Smith Corp.; Warren E. Jones, Management

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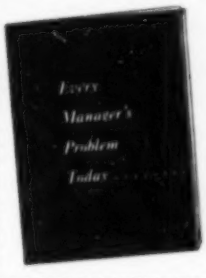

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Controls; Harvey Maxwell, Caterpillar Tractor Co.; Ray Morris, International Harvester Co.; Bert Seipel, Studebaker-Packard Corp.; and Louis Vollenweider, Deere and Co.

Milwaukee section member Evan Sheele, Marquette University Management Center, presented a quality control talk before the Fox Valley Society of Industrial Engineers at Oshkosh, Wisconsin, on Sept. 15. Evan's presentation, "The relationship of industrial engineering to quality control," is just another indication that SQC has come of age.

The N. E. Indiana section has instituted a program designed to stimulate membership interest in various phases of QC. At each of the monthly meetings, a speaker will be given an opportunity to present a fifteen minute "one-two punch" on the wide application of the "moving range of two." This program has received a successful kick-off by R. N. Snyder, quality control engineer, International Harvester Co., Fort Wayne. The educational committee, under the chairmanship of Mr. Snyder, has listed a full complement of speakers to present direct application utilizing this method.

The educational committee will also act as an aid to the membership committee in preparing information to answer the question, "Why should I belong to the ASQC?"

The Philadelphia section certainly can lay claim to having a high distribution of teaching members as the following will prove: Stan Wirtschafter and Andy Irvine — Villanova University; Leo Jacobson and Len Kurfuerst—Temple University; Dick Jacobs and Gordon Beckhart—RCA in-plant training course; besides these, there are also five full time professors as members of this section.

Paul T. Burdett, a charter member of the Seattle section, has been promoted to a staff position as statistical quality control analyst, directorate of procurement and production, Hill AF Base, Utah. Mr. Burdett was formerly quality analyst, USAF, quality control division in Seattle.

C. T. Shewell, senior member, South Texas section, was elected by the chemical division as counsellor for district 14. Mr. Shewell, Humble Oil & Refining Co., is to present a paper at the Tenth Annual Convention of the society in Montreal on "Experimental designs in paper studies of catalytic cracking."

The section development committee of the Southern Connecticut section with Anthony J. D'Apice, chairman, has come up with some excellent ideas to further section development which should be of interest to other sections. One is the use of two colored identification cards at the monthly meetings; one member and one non-member. The object of this is to simplify contact by executive committee members with non-members with the objective of creating an atmosphere of cordial hospitality and the creation of good will. The other idea is to obtain a tabulated list of industries in the area, grouping like industries together. This list serves the following purposes: contact of interested individuals in these industries and inviting them to regular monthly meetings which are of interest to them; and follow up action by the membership committee of those individuals who respond to these contacts with the objective of obtaining their membership in the section.

Francis Olson, Worcester section, is chairman of the exhibits for the Ninth New England conference which will be held in Hartford, Conn. According to Mr. Olson, the arrangements are in the final stages.

Martin W. Rogers, Boston section, has been appointed to the post of director of quality control of the National Co., Inc., Malden and Melrose, Mass., electronics manufacturer. Mr. Rogers was formerly manager of quality control engineering for the Raytheon Manufacturing Co.

Vernon P. Ahier, treasurer for the Youngstown section for three years, died of a heart ailment on Nov. 29. Vern was one of the Charter Members of the section and gave generously of his time to make the section a success.

Bibliography

JOSEPH MOVSHIN, *Editor*
Assisted by the Editorial Committee, St. Louis Section, ASQC

On matters concerning the Bibliography Department, send correspondence, suggestions, and contributions to:
Joseph Movshin
9220 Old Bonhomme Road
St. Louis 24, Mo.

APPLICATION—
ELECTRICAL INDUSTRY

QUALITY CONTROL AS RELATED TO DESIGN, by A. H. Morgan and D. H. Harris (Electrical Manufacturing—v. 56, n. 2, Aug. 1955, p. 113-8)

This article discusses the steps in the development of a new product. It shows how quality control techniques are applied to various problems in setting up for manufacturing a new product.

APPLICATION—
TEXTILE INDUSTRY

HOW TO SET STANDARDS FOR WASTE CONTROL, by Norbert Lloyd Enrick
(Modern Textiles Magazine—v. 36, n. 9, Sept. 1955, p. 87-106)

This article is the seventh in a series discussing the problem of quality control in a textile mill. In this particular issue, the establishment of standards for waste is discussed. A series of standards in percent are given for many defects and operations in spinning and weaving. Control of reworkable waste is also considered. Some of the advantages and savings through such standards and control is indicated.

STATISTICAL QUALITY CONTROL IN FILAMENT WEAVING PLANT, by E. R. Bechner
(Textile World—v. 105, n. 5, May 1955, p. 131)

This article discusses a program developed for the acceptance of yarn. It includes consideration of acceptance criteria, testing pro-

cedure standardization, and control of rejects (seconds).

HOW MUCH TESTING SHOULD A MILL DO?, By N. L. Enrick (Textile Industries—v. 36, n. 9, Sept. 1955)

This article discusses the question of sampling error and the problem of basing decisions on relatively small samples. An allowable sampling error in percent is discussed along with an acceptable sampling risk. Tables are given wherein the number of tests required for a given allowable sampling error in percent, and a given coefficient of variation can be found. The coefficient of variation is obtained by converting range with a factor also given in a table.

Selected references in the Bibliography of *Industrial Quality Control* are obtained from the following sources:

The International Statistical Institute, *International Journal of Abstracts on Statistical Methods in Industry.*

ENGINEERING AND EXPERIMENTS

HOW TO DESIGN EFFECTIVE EXPERIMENTS, by F. Proschan (Sylvania Electric Products Inc.) and A. B. Babcok, Jr. (The Borden Co.)
(Chemical Engineering—v. 2, n. 8, Aug. 1955, p. 191-198)

This article describes some of the considerations necessary to design experiments which will prove the most meaningful data with the least cost. The article presents complete detail on the concept of establishing and testing a hypothesis and the statistical techniques used for this purpose. Included are a table of random numbers, factors for allowances in randomized block and factorial design, and factors for allowances in completely randomized designs. The use of these tables in designed experiments using block and factorial designs as well as randomized designs is discussed in some detail and illustrated.

INDUSTRIAL MANAGEMENT

COST YARDSTICK, by Guerin A. Bernardin (Vice President, Bernardin Bottle Cap Co., Inc.)
(Production—v. 36, n. 4, Oct. 1955, p. 87)

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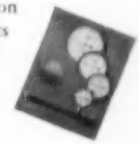

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which are the direct responsibility of individuals in departments from variations that are caused by other responsibilities. In this particular article, a series of charts are used to show breakdown of costs by various sources and areas of responsibility. Scatter diagrams are used to establish the relationship between production and employees of various categories. The line approximately showing the best relationship of these points is used as a standard curve. These can then be extended to departments and even over-all performance. This article stresses graphical techniques rather than statistical calculations as such.

STATISTICS

SOME MAKESHIFT METHODS OF ANALYSIS APPLIED TO COMPLEX EXPERIMENTAL RESULTS, by G. P. Davies and G. W. Sears

(Applied Statistics—v. III, n. 3, Nov. 1954, p. 47)

AN APPLICATION OF LINEAR PROGRAMMING TO THE SELECTION OF RAW MATERIALS, by N. Williams

(Applied Statistics—v. III, n. 3, Nov. 1954, p. 22)

A METHOD OF GRAPHING SALES FIGURES FOR EXECUTIVE USE, by A. W. Swan

(Applied Statistics—v. III, n. 3, Nov. 1954, p. 15)

THE ESTIMATION OF AN OPTIMUM SUBSAMPLING NUMBER, by Samuel H. Brooks

(Journal of the American Statistical Association—50, n. 270, June 1955, p. 398)

EXTENDED TABLES FOR USE WITH THE "G" TEST FOR MEANS, by J. Edward Jackson and Eleanor L. Ross

(Journal of the American Statistical Association—v. 50, n. 270, June 1955, p. 416)

THE PROPERTIES OF THE MEAN SQUARE SUCCESSIVE DIFFERENCE IN SAMPLES FROM VARIOUS POPULATIONS, by P. G. Moore

(Journal of the American Statistical Association—v. 50, n. 270, June 1955, p. 434)

PRACTICAL APPLICATIONS OF THE THEORY OF EXTREME VALUES, by Bradford F. Kimball

(Journal of the American Statistical Association—v. 50, n. 270, June 1955, p. 517)

SAMPLING PLANS FOR INSPECTION BY VARIABLES, by Gerald J. Lieberman and George J. Resnikoff

(Journal of the American Statistical Association—v. 50, n. 270, June 1955, p. 457)

PRACTICAL APPLICATIONS OF THE THEORY OF EXTREME VALUES, by Bradford F. Kimball

(Journal of the American Statistical Association—v. 50, n. 270, June 1955, p. 517)

ESTIMATE OF THE INTEGRATED NORMAL CURVE BY MINIMUM NORMIT CHI-SQUARE WITH PARTICULAR REFERENCE TO BIO-ASSAY, by Joseph Berkson

(Journal of the American Statistical Association—v. 50, n. 270, June 1955, p. 529)

RULES OF THUMB FOR DETERMINING EXPECTATIONS OF MEAN SQUARES IN ANALYSIS OF VARIANCE, by E. F. Schultz, Jr.

(Biometrics—v. 11, n. 2, June 1955, p. 123)

OPERATIONS RESEARCH

USE OF LINEAR PROGRAMMING IN SELECTIVE BLENDING STUDIES, by J. W. Davie (Esso Standard Oil Company)

(Econometrica—July 1955, p. 324-337)

The techniques of linear programming are used to set up and summarize experiments in selective blending on a day to day basis. Long range linear programs can be used to set optimum seasonal storage programs but component variability presents a different aspect of the problem in considering day to day blending.

THE TRIM PROBLEM: AN APPLICATION OF LINEAR PROGRAMMING TO THE MANUFACTURING OF NEWSPRINT PAPER, by A. E. Paull and John R. Walter (Abitibi Power and Paper Co. Ltd.)

(Econometrica—July 1955, p. 324-337)

In this paper, linear programming methods are used to control and reduce the amount of trim loss generated in cutting rolls of paper to meet customer's specifications. Six machines are involved in this study.

What's New?

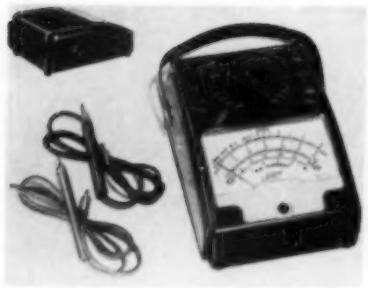
ROY A. WYLIE, *Editor*

News releases describing new products and literature should be sent to:
George R. Foster, Mng. Ed.
Room 6123 Plankinton Bldg.
161 W. Wisconsin Ave.
Milwaukee 3, Wis.

When inquiring about "What's New?" items, please mention INDUSTRIAL QUALITY CONTROL.

The Instrument Division, **Federal Telephone and Radio Co.**, 100 Kingsland Road, Clifton, N. J., have designed a tolerance indicator for rapid production testing of resistors, capacitors and inductors by comparison with an external standard. Direct readings in percent are given on a four inch meter with four tolerance ranges providing sensitivities as high as 2.5 percent full scale. Range of measurements include ten ohm to one megohm, ten uuf to one uf, and 100 uh to two mh with an accuracy of plus or minus five percent of full scale. With an accessory meter, sensitivity of 0.01 percent per division is available, equivalent to 0.5 percent full scale. Applications of this instrument include rapid matching of components for use in critical circuits, tracking of ganged capacitors and precision potentiometers and location of winding center-taps. The Tolerance Indicator can be used in measuring temperature co-efficients of resistors and capacitors. Special clips are provided to facilitate rapid insertion of components for test. Provision is also made for a foot operated test switch to completely free the operator's hands for the selection and insertion of components. Dimensions of the Tolerance Indicator are 12½ x 9 x 9 inches, and the weight is 15 pounds. The unit is self-contained and portable.

* * *



The Hickok Electrical Instrument Co., 10632 Dupont Ave., Cleveland 8, Ohio, are manufacturing a new, portable multimeter for laboratory engineers, inspectors, maintenance technicians and students. This instrument features a technique that protects both meter and the entire internal circuit against accidental burn-outs. In the event a dangerous overload is applied, the instrument disconnects itself and raises a re-set button on the case. Any high voltage may be applied directly across any function, including ohms, without any danger to the meter movement or associated components. The meter is available in two models:

Industrial Model 455—has a sensitivity of 20,000 ohms per volt a-c or d-c

Audio Model 456—has a sensitivity of 20,000 ohms per volt d-c and 1,000 ohms per volt a-c. Model 456 also includes DB ranges and has provisions for output measurements.

Both models incorporate a Full-Wave Bridge-type Rectifier Circuit. Batteries are housed in a special compartment which is accessible without removing case. No soldering is required. Batteries snap in and out with ease. The instrument case is molded: 8½ inches long, 5⅞ inches wide and height is 3 inches tapered down to 1¾ inches. Total weight is 3¾ pounds. A neoprene carrying case is available for either model to house instrument and leads.

* * *

George Scherr Optical Tools, Inc., 200 Lafayette St., New York 12, N. Y., have recently made available a small Precision Optical Rotary Table. The eight inch Optical Rotary Table is suitable for use in small precision machine tools and coordinate measuring instruments and also for difficult inspection set-ups on surface plates where accurate rotation in a horizontal plane must be combined with other measurements. The work-

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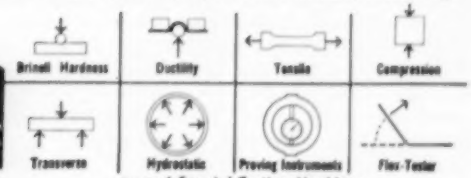
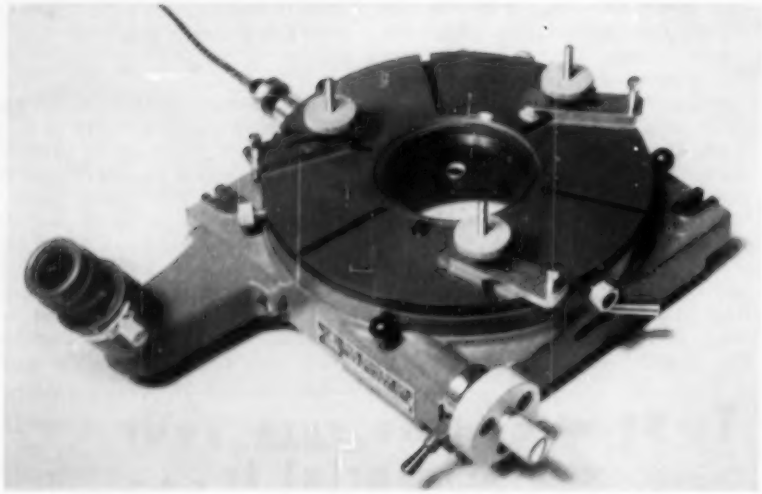
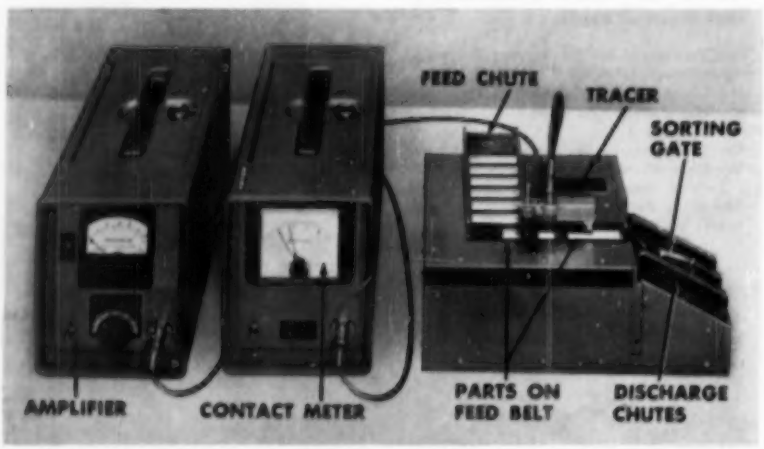


. . . and Special Testing Machines.



ing accuracy of the table is obtained optically and will therefore be maintained indefinitely. The master is a 360 degree Glass Circle which is set to and read through an optical vernier which is superimposed and adjustable for zeroing. The vernier scale reads in one minute of arc and 30 seconds of arc may be estimated. Guaranteed accuracy of the table is 30 seconds of arc. The inclined eyepiece has individual focusing and is illuminated by a low-voltage lamp against a green field. The table platen can be freely rotated by hand or by fine-adjustment worm and wheel with means for locking it in position. Six radial T-slots permit clamping of work and centering against built-in optical center mark.

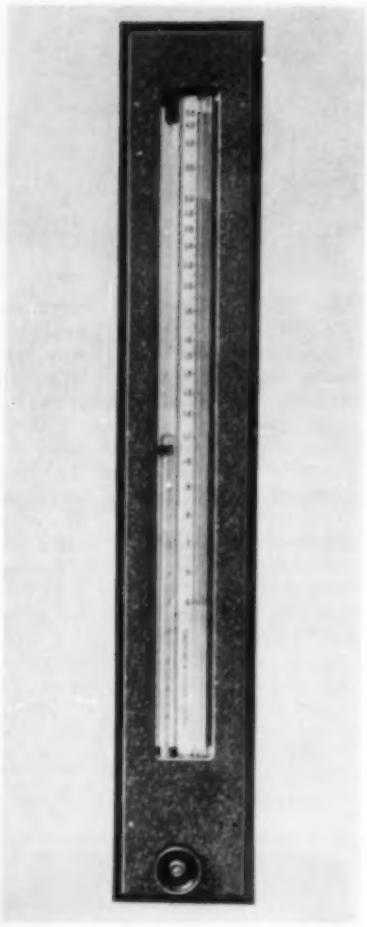
★ ★ ★



Automatic Profilometer equipment for sorting parts according to surface is now available from **Micrometrical Manufacturing Co.**, 345 South Main St., Ann Arbor, Mich. This equipment sorts parts in accordance with the microinch roughness measured along an outside diameter or flat surface, including tapers and parts with grooves or shoulders. Work-pieces are fed from a chute onto a conveyor belt which moves them beneath a Profilometer Tracer. As the parts leave the Tracer, they are automatically directed into an "accept" or "reject" discharge chute in accordance with their roughness. Equipment can be furnished to accept work within a selected range of roughness, rejecting parts that are too rough or too smooth. Each application is engineered to the user's individual requirements, and the details vary accordingly. However, each installation for use with external surfaces includes the basic elements identified in the accompanying photograph. In addition to the measuring-and-sorting equipment, the company can supply auxiliary items, including equipment for automatic selection of parts to be measured (such as every fifth or tenth part from the production line,) signal lights, and controls to shut down the line after a given number of parts are rejected.

★ ★ ★

A new Type II Viscometer for directly determining in a matter of



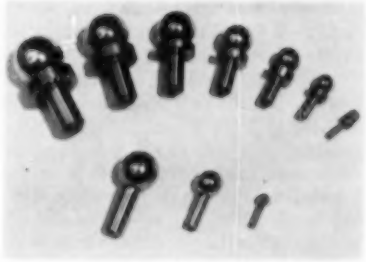
minutes the kinematic viscosity of fuels, light oils, and non-corrosive liquids, is now available for laboratory or field use, according to **Commercial Research Laboratories, Inc.**, 20 Bartlett Ave., Detroit 3, Mich. The flow system design employed in the new instrument makes possible readability within one percent of indicated viscosity at any point of the scale. Ranges of the Type II are 0.5 to 5.0 and 2.0 to 30 centistokes permitting its use for measurement of all liquids used in testing aircraft fuel and hydraulic system components. The Type II is supplied as a portable unit for laboratory or field use, or as a panel-mounted unit for use on either new or existing test equipment. Its maximum weight of eight pounds includes thermometer, filter, filter cartridge, and AN outlet fittings. No other laboratory instruments are required and no special operating skill is needed to obtain immediate and consistently accurate readings.

★ ★ ★

Lightning Calculator Co., Box 6192, St. Petersburg Beach 6, Fla., have announced an improved version of

the Koechel Quincunx. This device is used as a quality control training aid for visualizing the creation of a normal distribution pattern and for demonstrating sampling techniques of variables sampling. The Quincunx is milled from solid mahogany, has a plastic front and utilizes iridescent red beads against a white background. Push button controls for dropping the beads, a control for varying the objective center, a self contained easel built into the back and a zipper carrying case are features of the new design. Total weight is four pounds and the unit is shipped in a plywood reusable container for later possible interplant shipment. Price of the Quincunx is $150.00. Information on this and other quality control training aids are available from the manufacturer.

* * *



Tooling balls that have shanks both with and without locating shoulders are announced by **Industrial Tectonics, Inc.**, Ann Arbor, Mich. The tooling balls are made of Type 440-C

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This 24" ROTAB plus centering fixture cuts checking time for 11 dimensions on six vane segments from several hours to 5 minutes each.

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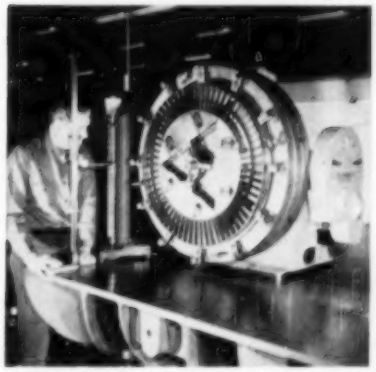

Seconds-of-arc precision allows quick, accurate inspection with low cost standard gages. Here 36" powered unit checks vane spacing.

For small parts inspection this 12" universal ROTAB minimizes setup and inspection time, does not require power for tilting and rotation.

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stainless steel hardened to 55-58 Rockwell C. Both types are carried in stock in ball sizes from ¼ inch through one inch by ⅛ inch increments. The balls with a plain shank are called fixture balls and are generally built into jigs and fixtures, where the center of the ball provides a positive locating point for positioning work in any plane. These balls are accurate to ± 0.0001 inches on size, the shanks are held to plus 0.0000 inches minus 0.0003 inches on diameter, and the ball and shank are concentric to 0.0002 inches total indicator reading. The balls with a reference shoulder (known as checking balls) are used for inspection purposes, and the distance from center of ball to bottom of shoulder is held to ± 0.0002 inches. The balls themselves are made to ± 0.00002 inches on size, the shanks are held to plus 0.0000 inches minus 0.0002 inches on diameter, and the ball and shank are concentric to 0.0002 inches total indicator reading. A price list and dimensioned drawings of these standard tooling balls are available on request from the manufacturer. Tooling balls of both types can also be furnished in non-standard sizes or with modifications as required.

* * *

Allied Engineering Div., Allied International, Inc., South Norwalk, Conn., have developed the Model 302C regulated, portable power supply to provide controlled power output at low cost. Small and lightweight, the new unit features excellent regulation over a wide voltage range with less than three millivolts ripple. A dual scale meter, stand-by switch, pilot light and fuse protection are standard accessories. Over 400 volts at 90 milliamperes can be obtained for intermittent periods. To double voltage output, two units may be operated in series, or any number may be paralleled to increase current capacity. A separate bias output is also provided, with independent regulation against line voltage variations. Recovery time is better than 15 milliseconds. One of three outputs may be obtained:

(a) 0-350 volts d-c at 20 milliamperes, continuously variable, with regulation less than ± 0.05 percent under variations of line and load combined; positive or negative may be grounded to chassis.

(b) 0-150 volts d-c at five milliamperes, continuously variable, regulation less than ± one percent with variations of line; positive internally connected to the negative of output #1.

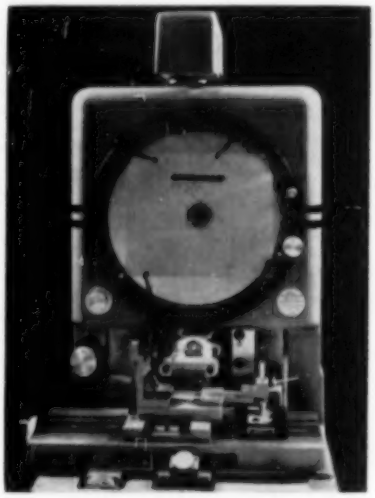
(c) 6.3 volts a-c at five amps, unregulated, center-tapped. Input is 105-125 volts, 50-60 cycle, 150 watt max.

The cabinet measures 5 x 8½ x 6 inches and weight is 12½ pounds. The price is $109.00 FOB South Norwalk, Conn.

* * *

Dayton Rogers Manufacturing Co., 2824-13th Avenue South, Minneapolis 7, Minn., are offering free to production and inspection people in metal working industries, their standard screw gauge and round stock calibrator. This gauge will calibrate immediately all sizes of both machine and wood screws from #0 through #14. It also has a calibrated scale by 32nds for calibrating all kinds of round stock. Sixty-fourths can be estimated. Requests for this gauge should be made on company letterhead.

* * *



Many parts, heretofore thought too difficult for inspection on contour projectors, are now being accurately gaged by reticle tracing fixtures recently introduced by **Optical Gaging Products, Inc.,** 26 Forbes St., Rochester, N. Y. By using the tracing principle, the part itself need not be projected; only an actual size outline of the part with tolerances appears on the comparator screen. This outline, reproduced on clear glass and projected on the comparator screen, is called a reticle. A tracer stylus, linked rigidly to the reticle, explores all configurations of the part to be inspected, such as hole locations, recesses, undercuts, internal profiles, cam surfaces, etc. Projection is independent of part size and any desired magnification can be used on the projector. Four standard reticle tracer units are being introduced. They are applied to the inspection of such parts as: hole locations in large castings profile and timing of cam lobes, groove form in ball nuts and aircraft propeller hubs, chamber contours in gun barrels, die contours, etc. Bulletins describing the principle of reticle type tracers are available from the manufacturer.

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New Literature

Pratt & Whitney Division, Niles-Bement-Pond Co., West Hartford 1, Conn., have published two new catalogs. The first covers Pratt & Whitney Sigmatic multi-dimension gaging machines for in-process and final inspection gaging. The second explains Air-O-Limit comparators and their many applications to production and inspection equipment.

Freeland Gauge Co., 9940 Freeland Ave., Detroit 27, Mich., recently published an 8-page brochure illustrating and describing a variety of standard and special gages and measurement control methods. The brochure contains photographs of special and built-up gages, special air gage fixtures and unusual air gage applications designed, engineered and built by the Freeland Gauge Company for automotive, aircraft and metal working industries.

A new catalog on Boice dial gages and setmasters is now available from the Boice Manufacturing Co., Staatsburg, N. Y. In addition to specific details of the company's line of snap, bore, large diameter and length gages and their companion setmasters, the catalog features ruled sketch sheets, making it easy for manufacturers to present their gaging problems to Boice.

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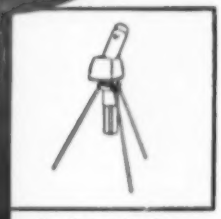
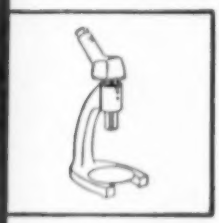
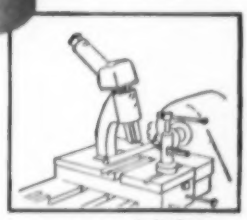


Use it in tripod...



in microscope stand...



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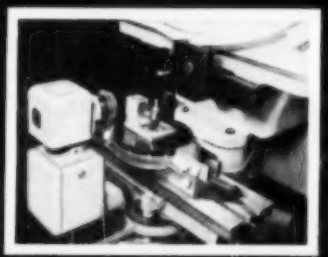
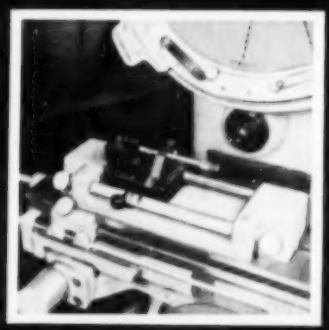


A J & L Comparator, with special fixture and chart, easily and perfectly measures a 3-dimensional cam. This is traditionally one of the most difficult of all inspection jobs.

This inexpensive J & L Comparator is precisely measuring four small parts, of different sizes, with the same setup.



Shoulder lengths can be measured to closest tolerance swiftly and accurately with a J & L Comparator. The fixture shown here accommodates a wide variety of parts.

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- ☐ Please send me Comparator Catalog 402-C (describes complete line). I'd like to see a showing of the movie(s)
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